CHAPTER 3
AFFECTED ENVIRONMENT
AND ENVIRONMENTAL CONSEQUENCES

3.0 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

This chapter describes the environment that would be affected by the development of the Proposed Action and the No Action Alternative. The environmental baseline information summarized in this chapter was obtained from field and laboratory studies of the project area, published sources, unpublished materials, and communication with relevant government agencies and private individuals with knowledge of the area. The affected environment for individual resources was delineated based on the area of potential direct and indirect environmental impacts for the proposed project. For some resources, such as geology and soils, the affected area was determined to be the physical location and immediate vicinity of the areas to be disturbed by the project. For other resources, such as water resources, air quality, and social and economic values, the affected environment comprised a larger area (i.e., watershed, airshed, local communities, etc.).

This chapter also describes the anticipated direct, indirect, and cumulative impacts of the Proposed Action and the No Action Alternative. Evaluation of potential impacts assumes the implementation of Alcoa's proposed environmental protection measures (see **Table 2-15** and Appendix F). Potential additional monitoring and mitigation measures for identified impacts are recommended by the USACE for individual resources. These measures are not part of Alcoa's proposed project but could be added as special conditions to any Section 404 permit that may be issued by the USACE or as stipulations of approval or authorizations of other regulatory agencies. This chapter also identifies residual adverse effects, that is, the effects that would remain after the proposed environmental protection measures and additional recommended mitigation measures have been implemented.

The proposed project may result in impacts interrelated with other past, present, and reasonably foreseeable future actions in the area. For resources where project-specific impacts are identified, the cumulative impacts associated with the proposed project were evaluated together with other interrelated projects. The period of potential cumulative impact is defined as the 25-year life of the project plus approximately 10 years for reclamation.

This chapter is organized by environmental resource. Sections 3.1 through 3.15 describe the existing conditions and potential environmental impacts associated with each resource. The short-term use of the environment relative to the long-term productivity of resources is discussed in Section 3.16. Short-term is defined as the 25-year period of project construction and operations and 10-year period of reclamation. Long-term effects on productivity are defined as effects that would continue post-reclamation (i.e., beyond 40 years). The irreversible or irretrievable commitment of resources is described in Section 3.17.

Numerous technical reports were prepared as support documents to this EIS. Copies of these technical reports are available for review at the following location:

- Regulatory Branch
U.S. Army Corps of Engineers,
Fort Worth District
819 Taylor Street, Room 3A37
P.O. Box 17300
Fort Worth, Texas 76102-0300

3.1 Geology and Mineral Resources

Environmental issues associated with geology and mineral resources include topographical changes to the project area, the potential impact of geologic hazards to project facilities, and the effects of removal of mineral resources from the project area.

3.1.1 Affected Environment

3.1.1.1 Physiographic and Topographic Setting

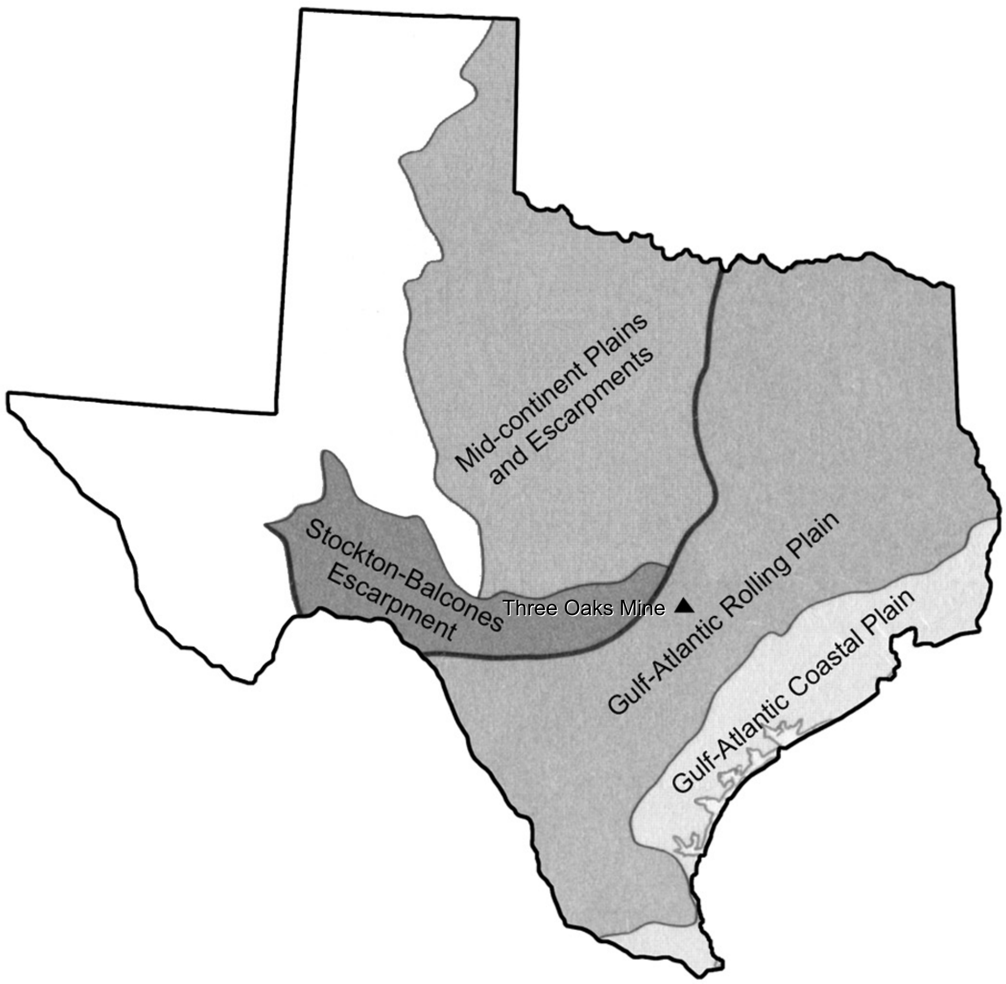
The Three Oaks Mine permit area is located in the Gulf-Atlantic Rolling Plains physiographic subdivision (**Figure 3.1-1**) (United States Geological Survey [USGS] 1970). The Gulf-Atlantic Rolling Plains subdivision in Texas extends southwest to northeast from the Rio Grande to East Texas and is bounded on the southeast by the Gulf Coastal Plain and on the northwest by the mid-continent Plains and the Stockton-Balcones Escarpment. In Texas, the Gulf-Atlantic Rolling Plains subdivision is characterized by gently rolling hills that are transected by northwest to southeast river systems that drain into the Gulf of Mexico. Major topographic features in areas between the river valleys are cuestas, asymmetric ridges with long slight slopes, to the southeast and relatively sharp topographic breaks to the northwest.

The study area for geology encompasses the Three Oaks Mine permit area. The permit area lies in a region called the Blackland Prairies that is bounded on the southeast by the Carrizo Ridge and by the Balcones Escarpment on the southwest (**Figure 3.1-2**) (Spearing 1991). The Carrizo Ridge is a cuesta that is evident for many miles. Elevations in the permit area range from 450 to 600 feet national geodetic vertical datum (NGVD), and the area is characterized by low-lying hills that are cut by generally east to southeast trending drainages. The cumulative effects area includes the permit area in addition to other mining projects in the East-Central Texas lignite area.

3.1.1.2 Regional Geologic Setting

A major feature of Texas geology is the Ouachita Fold Belt, a buried mountain range that extends from southeast Oklahoma to the Big Bend area of West Texas (**Figure 3.1-3**). Other major structural elements in East-Central Texas include several major fault zones and basins. Coincident with the buried Ouchita Fold Belt is a hingeline along which parallel fault zones occur (Davis et al. 1989). These fault zones are the Balcones Fault Zone, Luling Fault Zone, and Mexia Fault Zone. In addition to these fault zones, other major structural elements in the East-Central Texas area are the East Texas Embayment, Sabine Uplift, and the Gulf Coast Basin.

The Ouachita Fold Belt marks the edge of the North American continent at the end of the Jurassic and beginning of Cretaceous periods 144 million years ago (Spearing 1991). The pulling apart of the North and South American continents caused the appearance of a shallow sea that was to eventually become the Gulf of Mexico. During late middle Jurassic, sediments called evaporites were deposited in this shallow sea over the northern Gulf of Mexico region (Worrall and Snelson 1989). These deposits, known as the Louann Salt, originally may have been 5,000 to 7,000 feet thick in East Texas (Jackson and Seni 1984). Later deposition



Source: USGS 1970.

Three Oaks Mine

Figure 3.1-1

Physiographic Subdivisions

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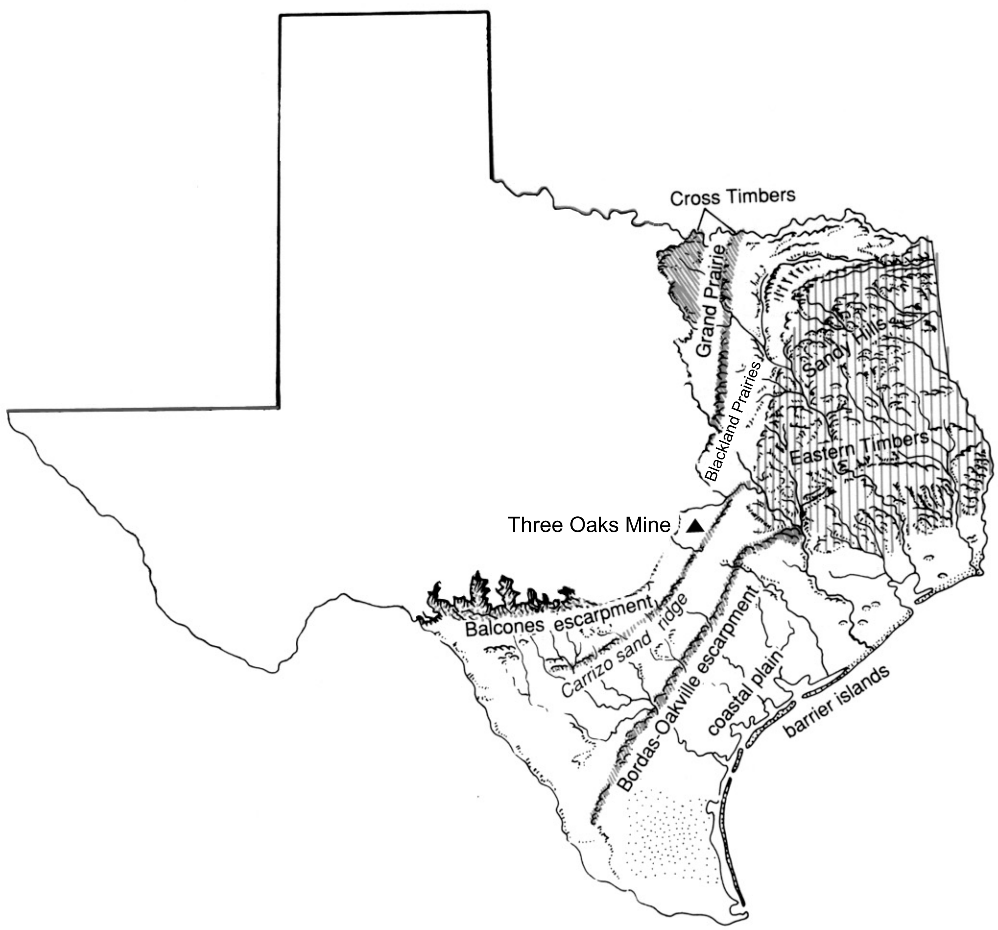

Source: Adapted from Spearing 1991.

N

0 100 200 Miles

Three Oaks Mine

Figure 3.1-2

Physiographic Features of East Texas

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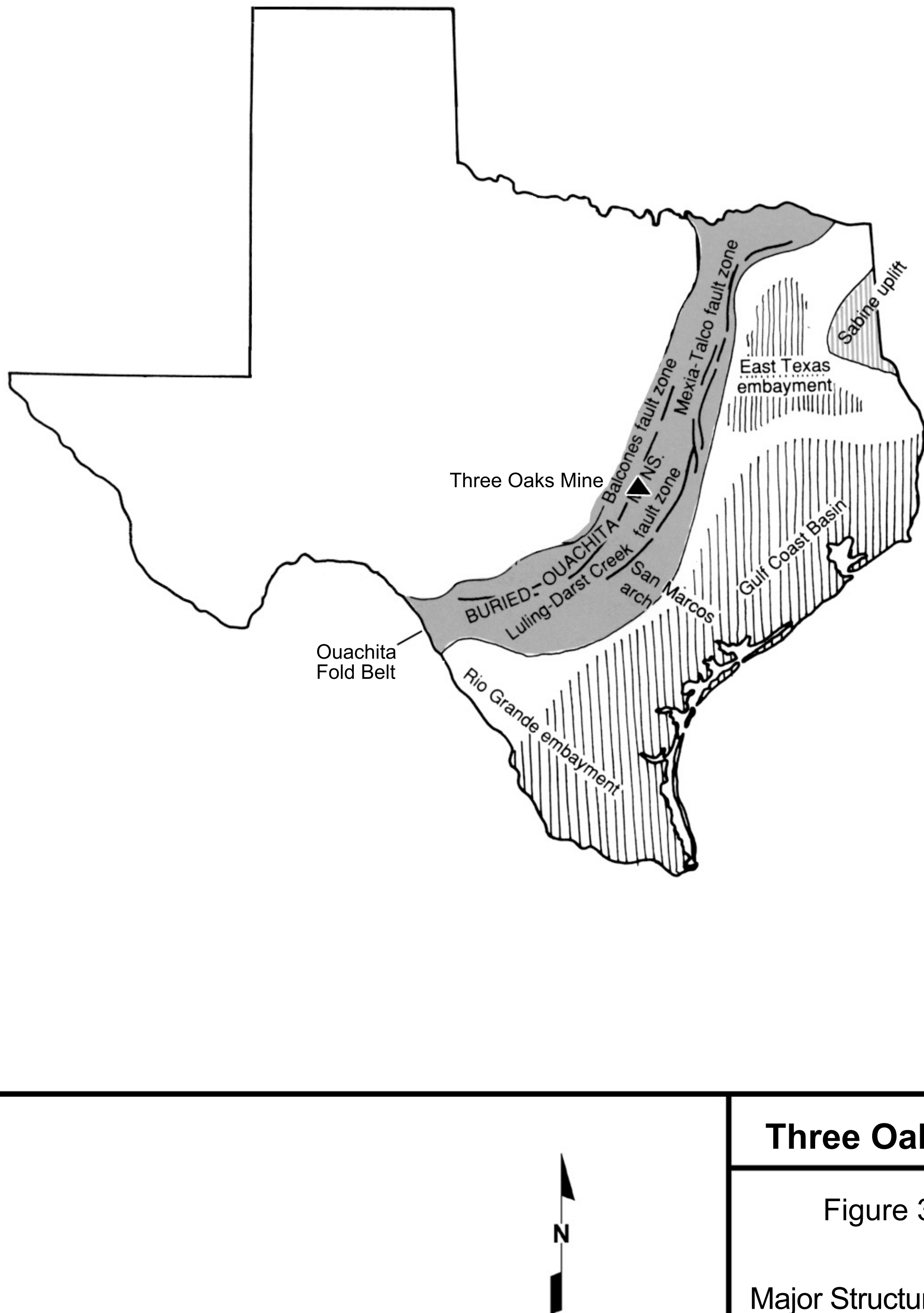


Source: Adapted from Spearing 1991.

Three Oaks Mine

Figure 3.1-3

Major Structural Features of East Texas

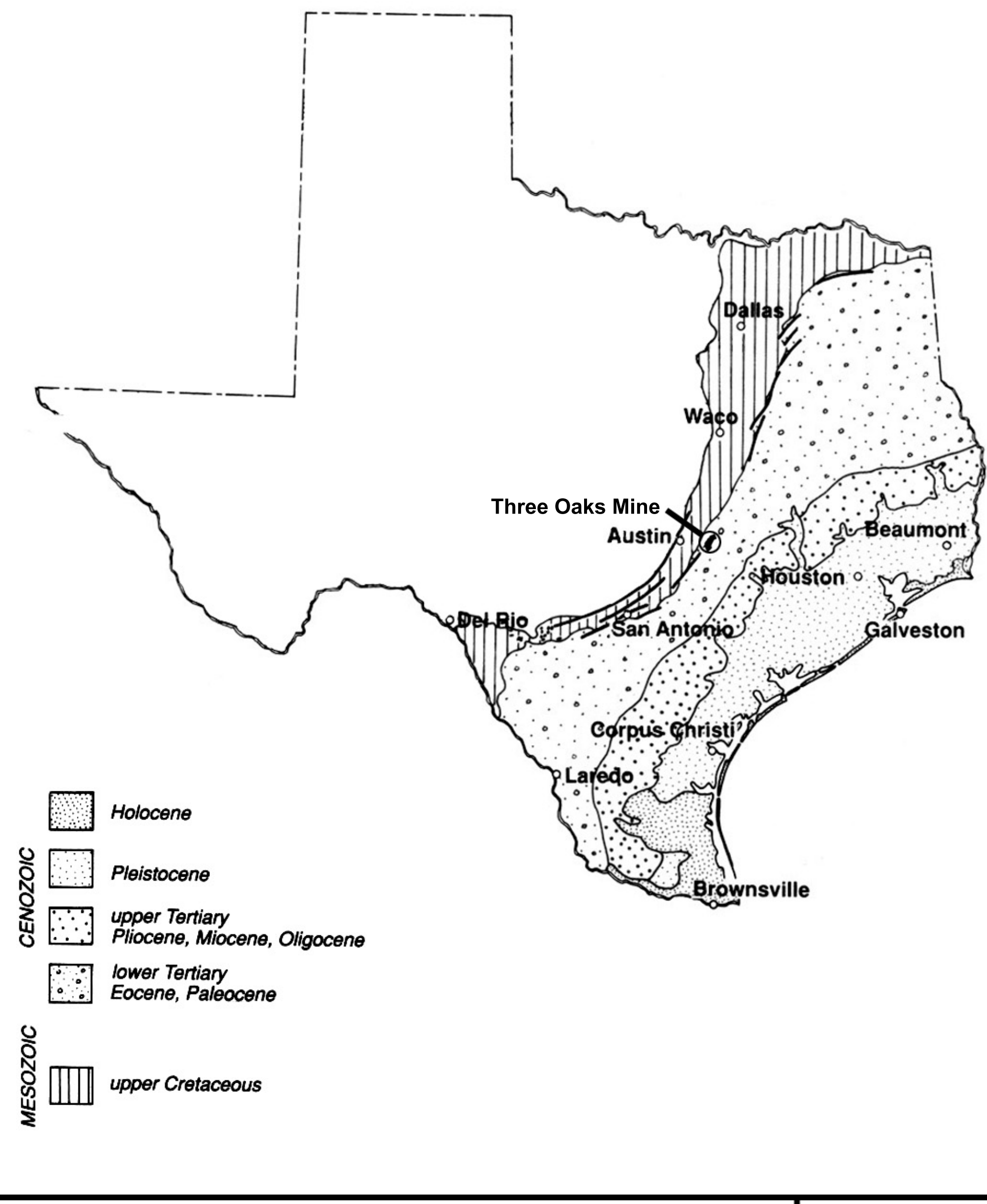
over the salt resulted in the creation of structures in the overlying sediments as well as influencing the depositional patterns in those sediments. During the Jurassic and lower Cretaceous periods, clastic and carbonate rocks were deposited along the fringes of this shallow sea. Carbonate rocks (limestone and dolomite) in this area are composed primarily of calcium and magnesium carbonate. The carbonate rocks, which were derived from the shells of various living organisms, developed in a complex of patch reefs, barrier reefs, and lagoonal environments. In upper Cretaceous time, shale, chalk, marl, and limestone were deposited, which are represented by the Eagle Ford, Austin, Taylor, and Navarro Groups (Worrall and Snelson 1989). The maximum aggregate thickness of these units in the area is approximately 1,900 feet (Proctor et al. 1974). At the close of the Cretaceous period, approximately 60 million years ago, uplift of the Rocky Mountains began and the deposition of carbonates ceased. Large river systems began carrying sediment eroded from the Rocky Mountains as they were uplifted. These river systems generally trended from northwest to southeast, and delta complexes were built over the Cretaceous deposits. The lowermost Tertiary unit, the Midway Group represents the first influx of sediment from these river systems that were to dominate Cenozoic deposition in the northern Gulf of Mexico (Worrall and Snelson 1989). The Midway Group is composed largely of clay that was deposited as pro-delta mud and is approximately 650 feet thick in the Central Texas area (Proctor et al. 1974). During the Tertiary period, the deltas built eastward and southward over time and deposited large amounts of sand and mud, similar to the modern Mississippi delta. These deposits have formed a large wedge of sediment that is tens of thousands of feet deep and thickens toward the Gulf of Mexico. The outcrops of these sedimentary units generally parallel the coast (**Figure 3.1-4**).

The geologic units relevant to the Three Oaks Mine are Eocene-age deposits of the Wilcox Group and the Carrizo Formation, the lowest unit of the Claiborne Group (**Figure 3.1-5**). The geologic units generally thicken toward the southeast and dip gently toward the Gulf of Mexico at a rate of 1 to 2 degrees (90 to 180 feet per mile).

The following discussion of the Wilcox Group and the Carrizo Formation (of the Claiborne Group) addresses an area along the Carrizo-Wilcox outcrop from just west of the Colorado River to northern Freestone County. Within this area the Wilcox Group is subdivided into the following formations: Hooper, Simsboro, and Calvert Bluff. Outside of the above-described area, the formations are no longer recognizable as distinct units. The deposits of the Wilcox Group are composed of sandstones, siltstones, mudstones, and lignites that were deposited in a fluvial-deltaic system (Fischer and McGowen 1967).

Hooper Formation

The Hooper Formation is the lowest unit of the Wilcox Group and is composed mostly of mudstone with minor amounts of fine- to medium-grained sandstone; this formation is generally about 500 feet thick (Thorkildson and Price 1991). The upper part of the Hooper Formation contains thin lignite seams. The Hooper was deposited in a fluvial-deltaic environment.

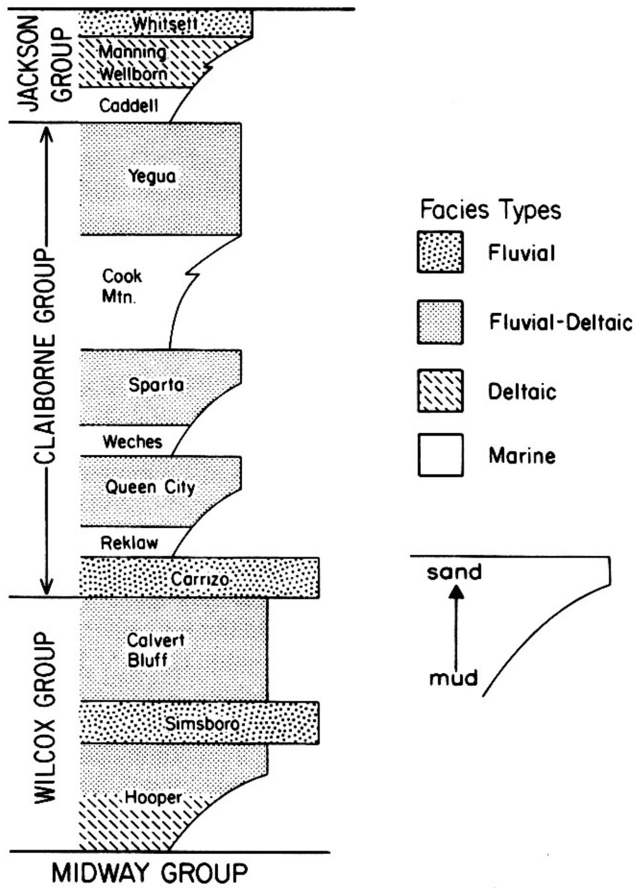


Source: Adapted from Spearing 1991.

Three Oaks Mine

Figure 3.1-4

Geologic Map of East Texas



Source: After Kaiser et al. 1991.

Three Oaks Mine

Figure 3.1-5

Eocene Units in East-Central Texas

Simsboro Formation

The Simsboro Formation is primarily composed of fine- to coarse-grained sand; also it contains lesser amounts of finer grained sand as well as silt and clay. The Simsboro Formation is up to 800 feet thick and was deposited in a fluvial system (Thorkildson and Price 1991). It consists of multiple thick channel deposits composed of sand with interchannel material consisting of finer grained material; also it contains minor lignite seams.

Calvert Bluff Formation

The Calvert Bluff Formation is the upper unit of the Wilcox Group and is primarily composed of mudstone with varying amounts of sandstone and lignite (Proctor et al. 1974). The Calvert Bluff ranges from 800 to 2,000 feet in thickness (Kaiser et al. 1980). Sand bodies occur in the Calvert Bluff; however, they are not widespread, as they occur in channel complexes. Lignite generally occurs in the lower portion of the Calvert Bluff Formation, between the channel complexes. The lignite is thought to have been originally deposited as organic-rich peats in swamps and floodbasins between the channel systems, similar to the modern Mississippi delta.

Carrizo Formation (Sand)

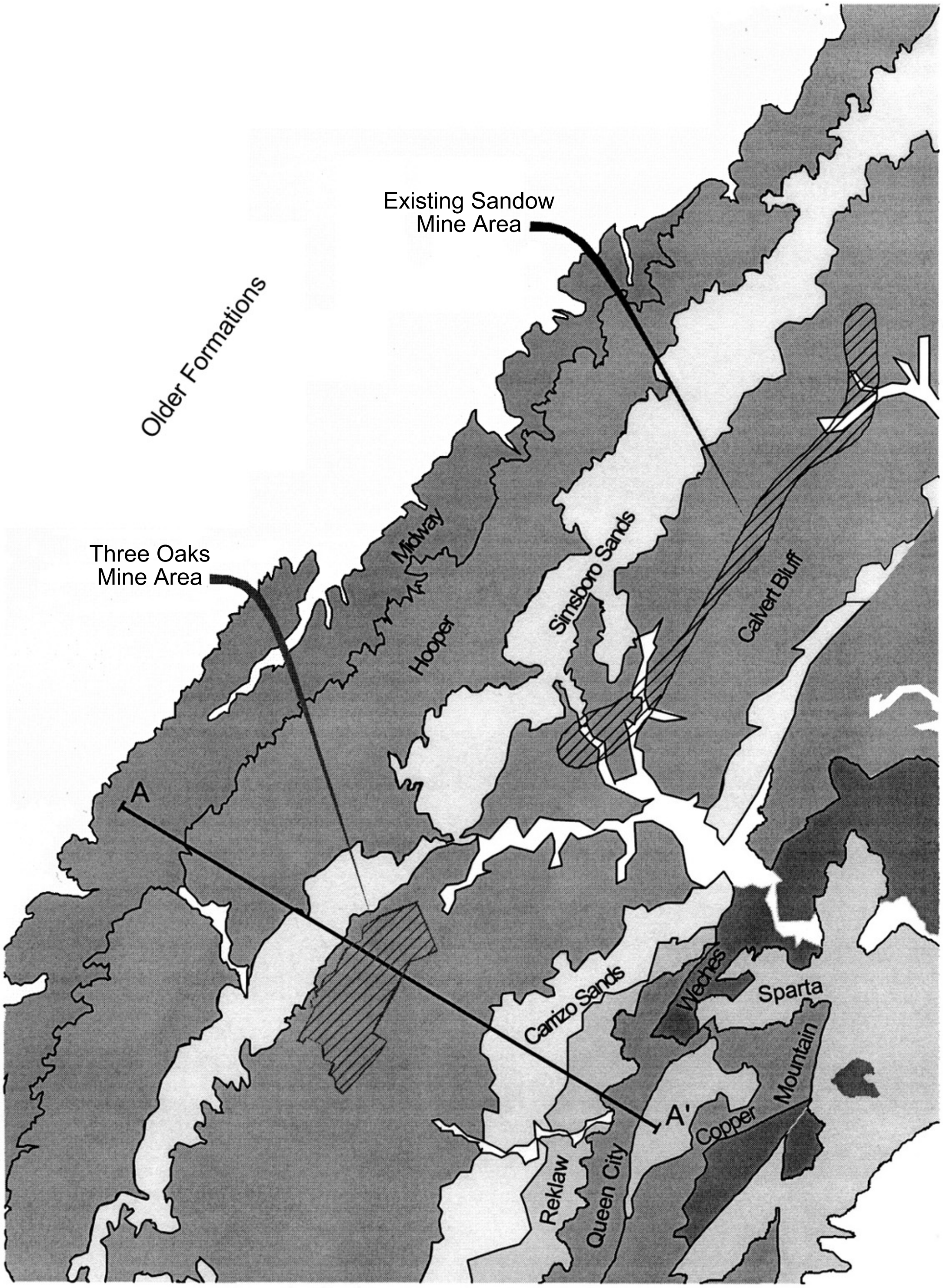
The Carrizo Formation forms the lowest part of the Claiborne Group. The Carrizo is primarily composed of fine- to medium-grained sand with lesser amounts of clay (Proctor et al. 1974). It is poorly cemented and varies from 100 to 150 feet in thickness (Ayers and Lewis 1985). The depositional environment of the Carrizo is uncertain but may consist of fluvial channels in the lower part grading to shoreline beach deposits in the upper part. In contrast to the Wilcox, the Carrizo appears to be a blanket deposit rather than discontinuous lenses of sand (Thorkildson and Price 1991). The Carrizo outcrop forms the Carrizo Ridge that was identified in the physiographic description above.

3.1.1.3 Site Geology

Stratigraphy

The Three Oaks Mine permit area lies almost entirely within the outcrop of the Calvert Bluff Formation (Alcoa 2000 [Volume 2]). The Hooper and Simsboro Formations underly the entire permit area, but the outcrops mainly occur outside of the permit area to the northwest (**Figures 3.1-6** and **3.1-7**). A small area of the Simsboro outcrops in the permit area.

As summarized above, the Calvert Bluff Formation consists of sands, silty sands, clay, and lignite. The sands occur as massive discontinuous lenses. The lignite within the Calvert Bluff that is targeted for mining occurs in the lower portion of the formation (Alcoa 2000 [Volume 2]). The lignite in the permit area is depicted in **Table 3.1-1**. There are eight lignite seams in the Calvert Bluff, the lowest of which (the L174 seam) is too thin and discontinuous to mine. The lignite seams occur in stratigraphic zones that generally include lignite at the base with layers of clay or thinly interbedded sand, silt, and clay up to the



Three Oaks Mine

Figure 3.1-6

Geologic Map of the Three Oaks Mine Vicinity

Source: Hodges 2001.

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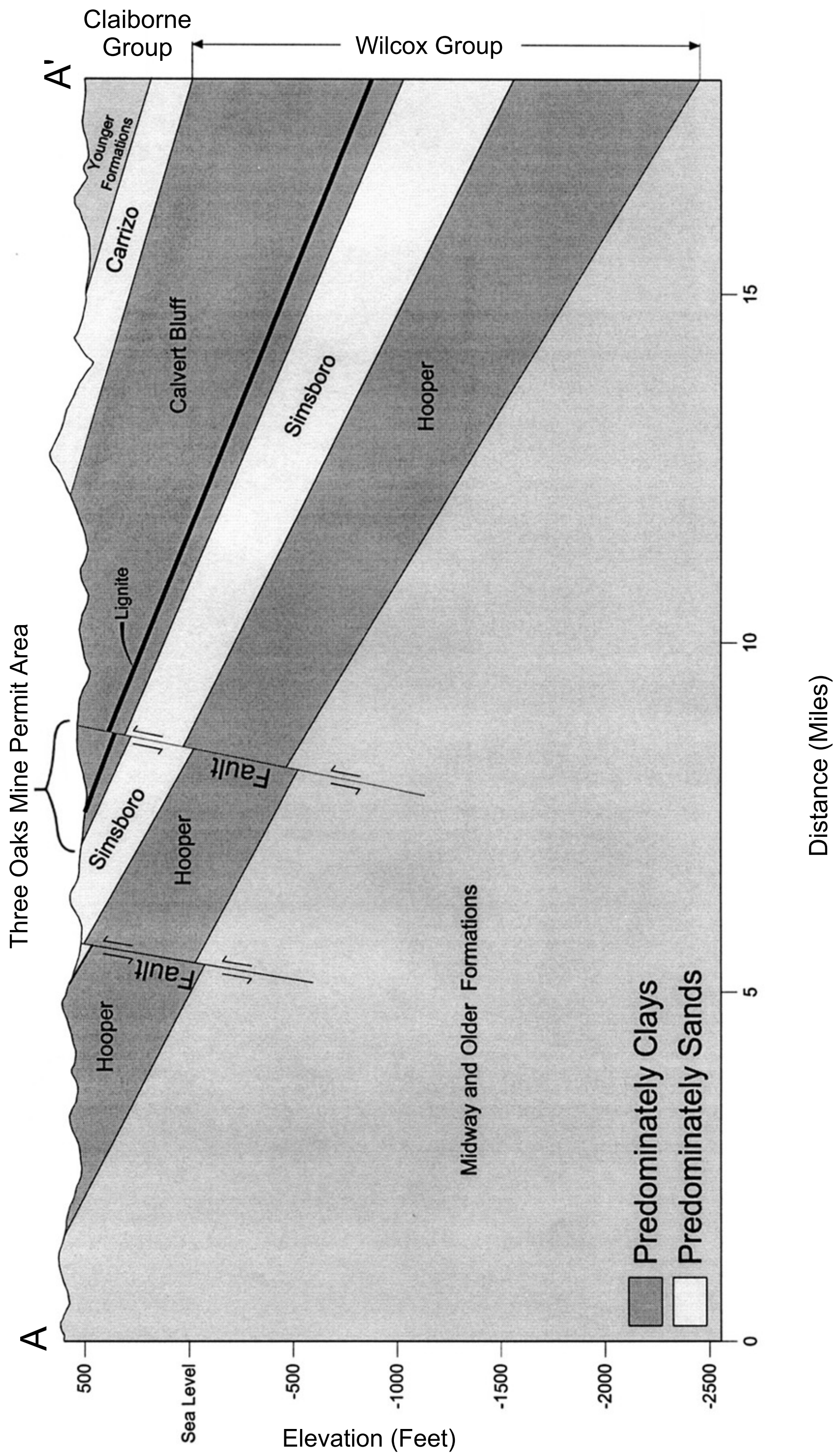


Notes:
15x Vertical Exaggeration.
Formation thicknesses and
fault displacements are approximate.

Source: Hodges 2001.

Three Oaks Mine

Figure 3.1-7

Three Oaks Mine Area
Geologic Cross-section
A-A'

Table 3.1-1
Major Lignite Seams Identified in the Permit Area

Formation	Lignite Seam	Average Thickness (feet)
Calvert Bluff	L800	3.5
	L700	5.2
	L600	4.1
	L500	5.8
	L400	5.1
	L300	5.7
	L200	6.6
	L174	1.4
Simsboro	L150	1.4
	L118	1.5
	L100	2.7

Source: Alcoa 2000 (Volume 2).

base of the next lignite seam. The material between the lignite seams is called interburden. In addition to the finer grained materials, there are occasional lenses of massive sand and silty sand in the interburden that are discontinuous. In the overburden, the material above the stratigraphically highest mineable lignite seam, the lithology of the Calvert Bluff is generally composed of clay or thin layers of interbedded sand, silt, clay, and silty clay. As in the interburden, there are occasional discontinuous lenses of sand and silty sand. A few lignite seams are present in the overburden, but they are thin and discontinuous (Alcoa 2000 [Volume 2]).

The Simsboro Formation is defined in the permit area as the first massive sand below the L200 lignite seam (or below the L300 seam in areas where the L200 is not present) (Alcoa 2000 [Volume 2]). The Simsboro in the permit area consists primarily of channel fluvial deposits consisting of clean sand (greater than 80 percent sand) up to 200 feet thick. The Simsboro also contains lesser amounts of thinly interbedded sand, silt, clay, and silty clay. The formation is sandier in the northern part of the permit area. Three lignite seams (L100, L118, L150) are present in the Simsboro; however, the seams are too thin and discontinuous to mine (**Table 3.1-1**). The Carrizo Formation does not outcrop or exist in the permit area; it outcrops approximately 3 miles to the southeast of the permit area.

Structure

Detailed subsurface data indicate that four normal faults cut through the geologic section within the permit area (Alcoa 2000 [Volume2]). The age of this post-depositional faulting has not been determined, but the faults most likely are related to flexure in front of the Ouchita Fold Belt and slippage along the up-dip pinchout of the Louann Salt. The local faulting appears to be parallel to the Luling-Mexia Fault zone (**Figure 3.1-3**) that occurs a few miles to the east of the permit area. Relative movement on the faults has brought some lignite seams closer to the surface in certain parts of the permit area.

3.1.1.4 Geologic Hazards

Seismicity

The project area is located in a Seismic Hazard Zone 0, the lowest seismic hazard risk (International Congress of Building Officials 1997). Historical earthquakes in the vicinity of Austin, Texas, have been attributed to the Balcones Fault Zone and the Luling Fault Zone (Davis et al. 1989). The earthquakes occurred more than 100 years ago and were of magnitude 4.0 on the Richter scale or less. Although there exists a potential for earthquakes to occur in the vicinity of the permit area, the potential ground motion is expected to be low, and resultant seismic hazards are considered to be minimal (Algermissen et al. 1990).

Landslides

The permit area is located in a region with low landslide susceptibility and low landslide incidence (Radbruch-Hall et al. 1982). Landslide hazards resulting from natural conditions are expected to be minimal.

3.1.1.5 Mineral Resources

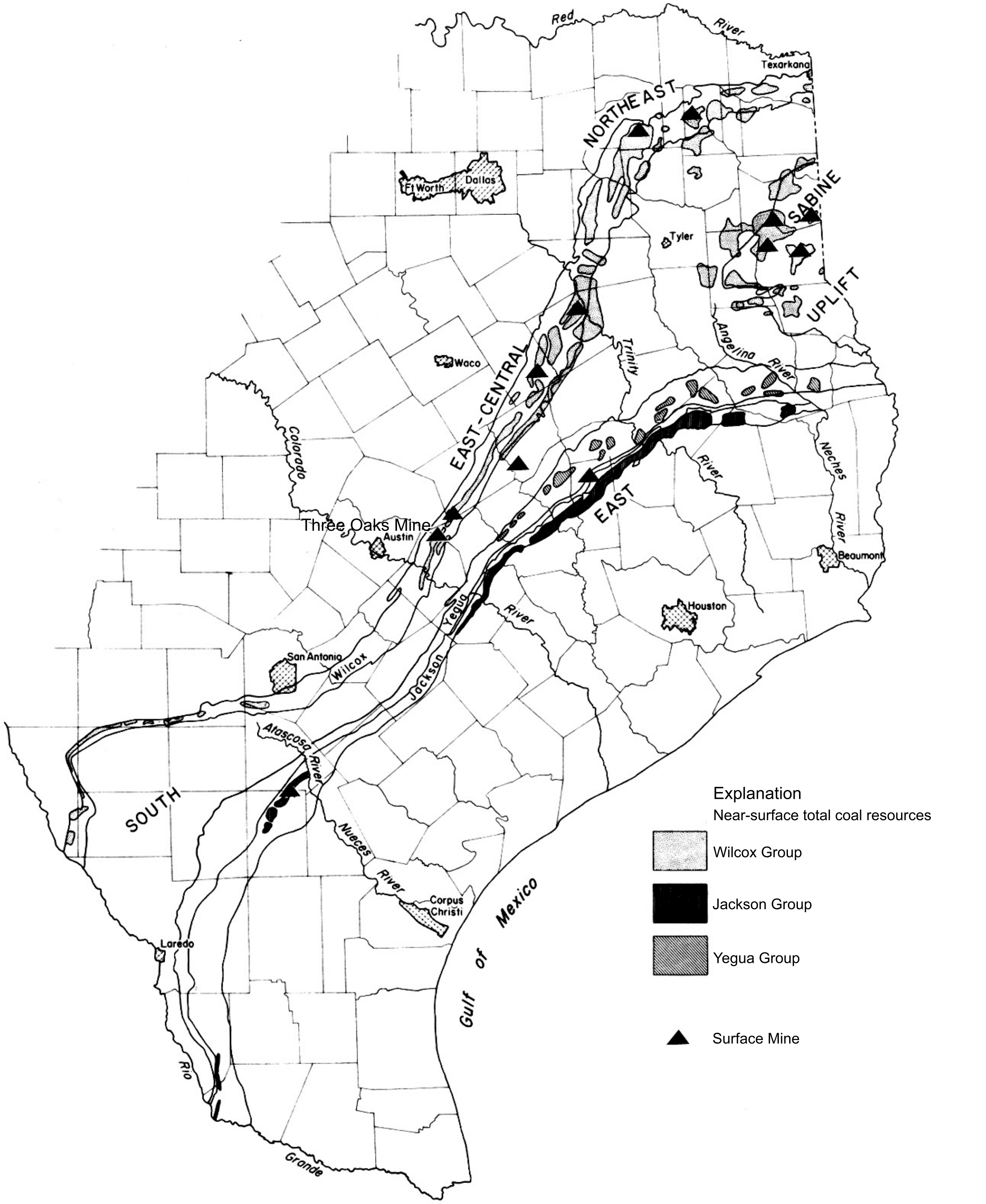
Lignite Resources

Near-surface (up to 200 feet deep) total coal resources (including lignite) in Texas are estimated to be 23.4 billion tons (Kaiser et al. 1980). The lignite resource is found in the Wilcox Group, the Yegua Formation, and the Jackson Group (**Figure 3.1-8**). The Wilcox Formation in the East-Central Region (as defined by Kaiser et al. 1980) contains approximately 28 percent, or 6.481 billion tons, of the near surface lignite resources. The East-Central Region extends from just west of the Colorado River in Bastrop County to northern Robertson County. The East-Central Region generally coincides with the area where the Wilcox is subdivided into the Hooper, Simsboro, and Calvert Bluff, although the Simsboro outcrop is recognizable further north into Freestone County (Ayers and Lewis 1985). The total lignite production from these resources between 1979 and 2000 are shown in **Figure 3.1-9**. The highest quality lignite is found in the Wilcox Group north of the Colorado River with heat content of approximately 6,500 British thermal unit per pound (BTU/lb). The lowest grade lignite is in the Jackson Group with a heat content of approximately 4,500 BTU/lb.

As described above, the mineable lignite in the permit area is found in seven seams. The lignite resource contains an average moisture content of approximately 32 percent, average ash content of approximately 19.1 percent, average sulfur content of 1.3 percent, and a heat content of 6,100 BTU/lb (Alcoa 2000 [Volume 2]). The mineable resource in the mine area consists of approximately 175 million tons (Alcoa 2000 [Volume 8]).

Oil and Gas Resources

There are no active oil or gas wells within the permit area; however, there are several abandoned oil and gas test wells (RRC 2001; Alcoa 2001b [Volume 2]). There are three active producing oil wells northwest of



Three Oaks Mine

Figure 3.1-8

Near-surface Total Coal Resources in Texas

Source: After Kaiser et al. 1980.

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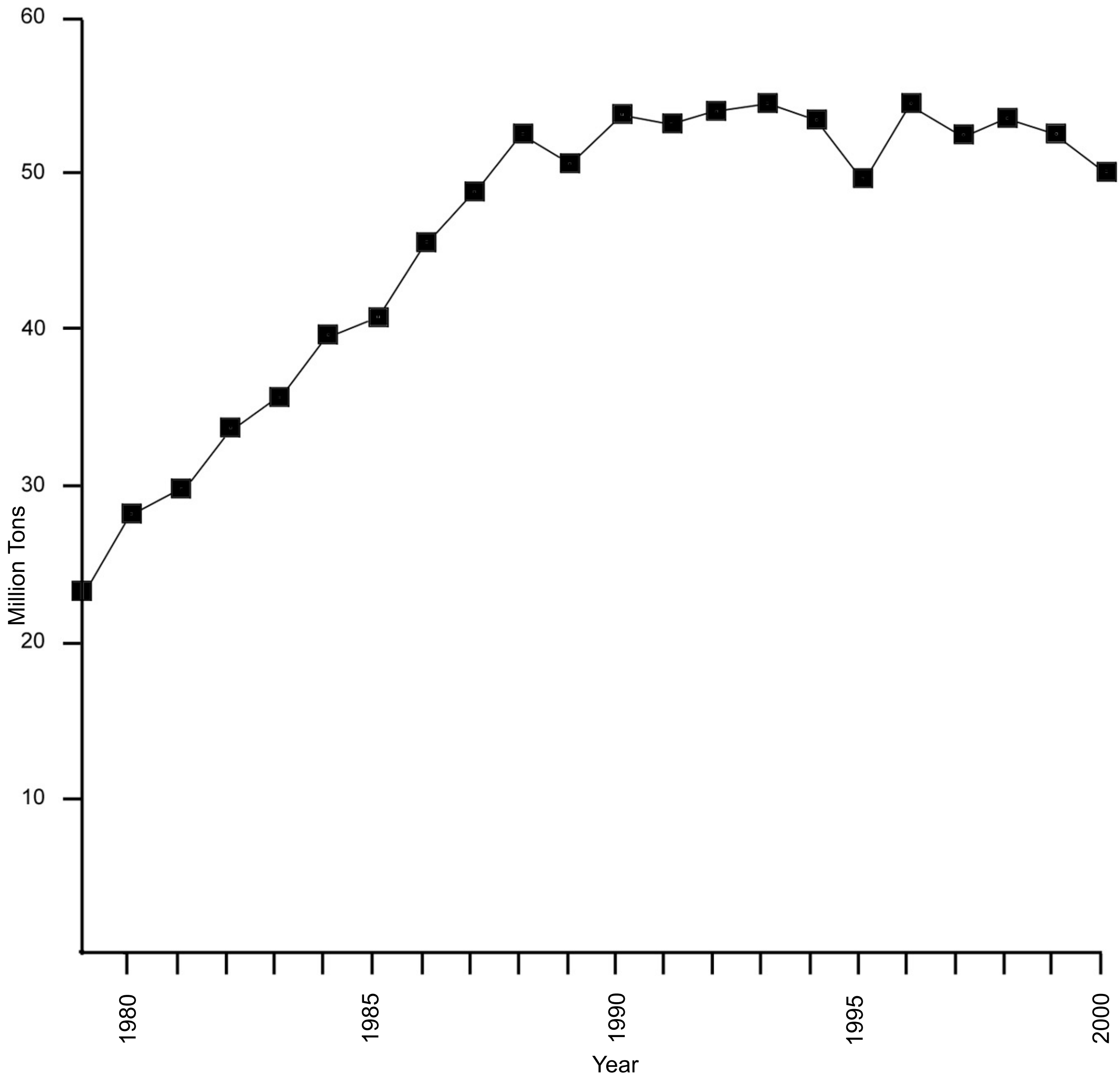

Source: Office of Surface Mining (OSM) 2001.

Three Oaks Mine

Figure 3.1-9

Texas Lignite Production
1979 to 2000

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the permit area in the Big Sandy Creek area in Bastrop County. There are no major oil and gas fields in the vicinity of the permit area, but there is potential for commercial oil and gas resources in the Cretaceous rocks that underlie the deposits of the Wilcox and Midway Groups (**Figure 3.1-5**). Sands in the lower part of the Midway have yielded commercial quantities of oil to the west of the permit area (Sellards 1929).

Industrial Minerals

There are several geologic units in the vicinity of the permit area that provide clay (Sellards 1929). These units are the Navarro (Cretaceous), Midway, Calvert Bluff, Yegua, and alluvial deposits. Development of local clay pits began in the 1870s to provide raw materials to the emerging brick industry (Alcoa 2000 [Volume 1]). The Butler Brick Company was founded in 1873 at the community of Butler and grew through acquisitions and mergers with other local brick manufacturers to become the current Elgin-Butler Brick Company. In the vicinity of the permit area, the Calvert Bluff Formation is the source of the clay used for brick and pottery, and clay pits and brick operations are present between the permit area boundary and U.S. Highway 290 (see Section 2.6.1.4).

3.1.2 Environmental Consequences

3.1.2.1 Proposed Action

Topography

The topography of the mine area would be altered considerably during mining activities due to the location of active mine pits and soil stockpiles. Reclamation plans provide for the restoration of the ground to approximate original contours to the extent possible. However, the topography in the vicinity of the end lakes permanently would be altered with the creation of more regular and rounded landforms having more uniform slopes and less drainage dissection.

Geology

In the mine area, lignite and overburden would be removed, and the original characteristics of the material would be permanently altered by the disruption of any existing stratification. Potential effects of this alteration are addressed in Section 3.3, Soils.

Geologic Hazards

Natural geologic hazards are not expected to affect the proposed project. The surface mine highwalls are anticipated to be stable and dewatering and depressurization are not anticipated to cause subsidence; therefore, the proposed project is not anticipated to create geologic hazards.

Mineral Resources

Lignite resources would be permanently removed from the mine area. Oil and gas resources beneath the mining area would not be affected; however, access to oil and gas resources temporarily would be constrained during active mining. There would be a loss of clay resources due to the removal and subsequent mixing of overburden materials from the Calvert Bluff Formation that would render the clay unsuitable for potential future processing into brick.

3.1.2.2 No Action Alternative

The impacts to topography, geology, and mineral resources as described for the Proposed Action would not occur under the No Action Alternative.

3.1.3 Cumulative Impacts

The past and present impacts to topography, geology, and mineral resources of the Sandow Mine are similar to the anticipated impacts of the Three Oaks Mine, since the Three Oaks Mine is replacing the Sandow Mine. Cumulatively, the Sandow and Three Oaks Mines would alter the topography of approximately 23,737 acres.

For almost 100 years, clay has been mined by Elgin-Butler Brick; the mining has impacted approximately 300 acres. A reported 80 years of clay reserves remain. Impacts from clay mining would occur whether or not the proposed Three Oaks Mine becomes operational and would contribute to cumulative impacts to mineral resources within the region.

Although oil and gas resources have not been discovered to-date in the mine area, economical resources may be present. Although mining operations may make potential future oil and gas drilling problematic, it would not preclude the recovery of oil and gas. Therefore, the Proposed Action would not result in cumulative impacts related to oil and gas production.

Potential cumulative impacts relate to potential future lignite mining of the Wilcox Group in the East-Central Texas lignite area as defined by Kaiser et al. (1980). The 175 million tons of lignite to be mined over 25 to 30 years at the Three Oaks Mine represents only 2.8 percent of the near-surface lignite resource of the Wilcox Group in East-Central Texas. In the late 1970s, projected lignite demand indicated a demand for 200 million tons of lignite per year by the year 2000 (BLM 1980a). U.S. Department of the Interior, OSM (2001) statistics indicate that Texas coal (primarily lignite) production peaked at 54.8 million tons in 1996 (**Figure 3.1-9**). Preliminary production estimates for the year 2000 indicated a production of 50 million tons. The graph in **Figure 3.1-9** shows no discernable upward trend for future lignite production. Lignite production at the Three Oaks Mine is intended to replace the production at the Sandow Mine. As a result, the Three Oaks Mine production would not incrementally increase overall Texas production. In addition, the RRC has indicated that other than the Three Oaks Mine, no other permit applications for new mines have been submitted, nor have any potential applicants approached the RRC concerning future mining in the Bastrop, Lee, and Milam Counties area (Walter 2001). The only recent exploration activity in the vicinity was an exploration registration that was filed to conduct exploration drilling northeast of the Sandow Mine in Milam County. Outside of the three-county (Bastrop, Lee, and Milam) area, TXU has an application pending with RRC for the proposed Twin Oaks Mine near Bremond, Texas. The proposed TXU Twin Oaks Mine would result in a small incremental increase in Texas lignite production of approximately 1 million tons per year from 2002 through 2011 (Jones 2002). Based on the lignite production trends in Texas and the foreseeable mining activity in the near future, the cumulative impacts of lignite mining at Three Oaks appear to be minimal.

3.1.4 Monitoring and Mitigation Measures

No additional monitoring or mitigation is being considered for geology or mineral resources. Alcoa proposes to regrade spoil piles to their approximate original contour, in compliance with RRC requirements.

3.1.5 Residual Adverse Effects

There would be no residual adverse effects to geology or mineral resources as a result of the proposed project.

3.2 Water Resources

The principal groundwater issues associated with the proposed Three Oaks Mine include the potential impacts of groundwater drawdown on water quantity and water quality in the affected aquifers. The principal surface water issues include the potential impacts to streams, seeps, and springs from groundwater drawdown and surface water discharge, and the potential impacts from mine-related surface disturbance and changes in watershed areas.

This section describes the affected environment for groundwater, surface water, and waters of the U.S. including wetlands. Highly technical information and data as well as descriptions of the groundwater models used for impact assessment are provided in Appendix C of this EIS.

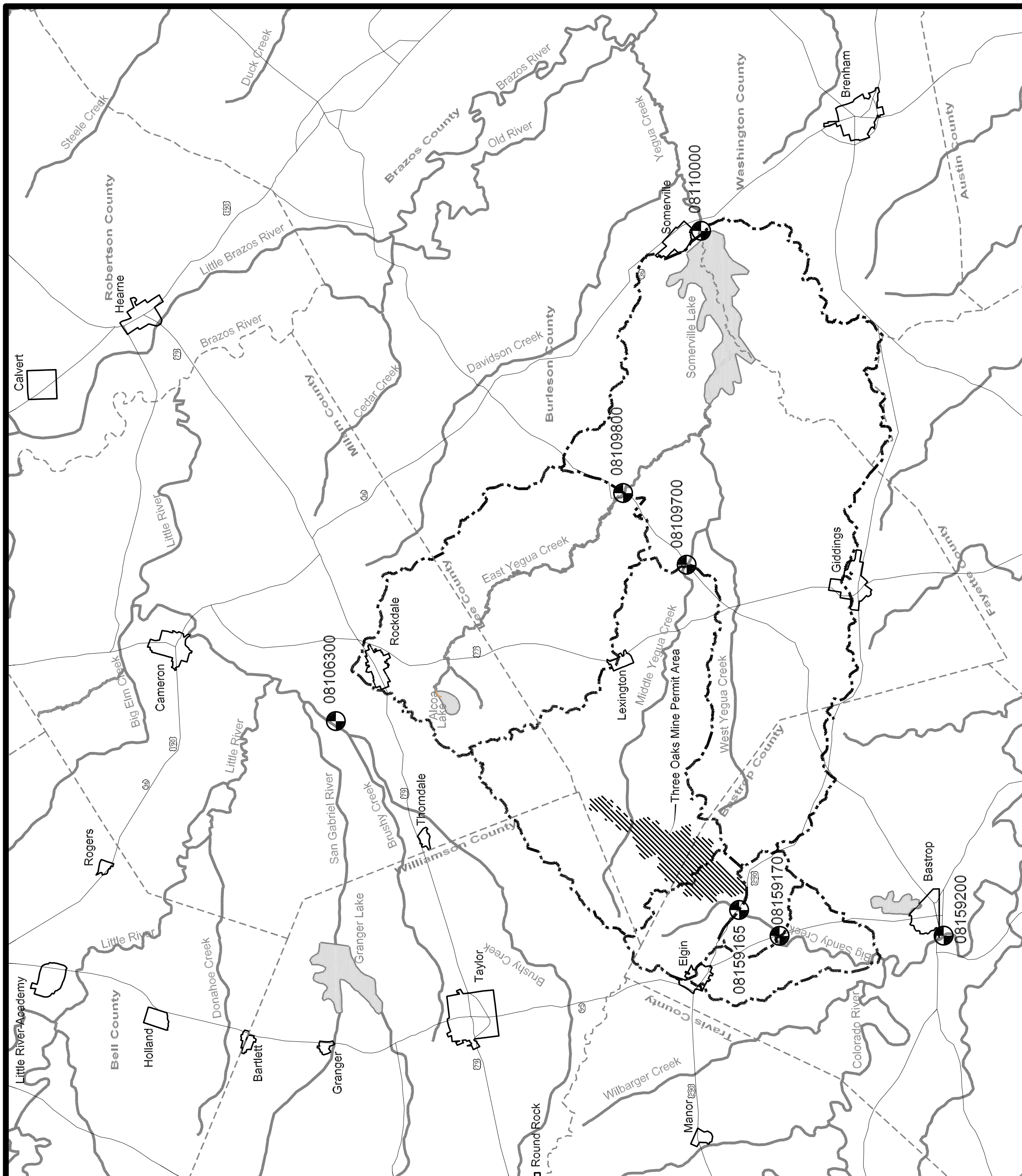
3.2.1 Hydrologic Setting

The proposed Three Oaks Mine is located in the Gulf Coastal Plains physiographic province of Texas (Bureau of Economic Geology 1996). The project area is located on the transition between two physiographic subprovinces, the Interior Coastal Plain and the Blackland Prairies. Topography in the region is dominated by rolling hills intersected by swales and wider alluvial valleys. Elevations in the proposed permit area range from 435 to 565 feet NGVD, and both higher and lower elevations occur in the region around the permit area. The Three Oaks Mine permit area drains to both the lower Colorado River drainage to the west and south and to the Brazos River drainage to the north and east (see **Figure 3.2-1**). Within the region, the divide trends generally from west-northwest north of Elgin to east-southeast near McDade. Elevations along this divide reach approximately 650 feet NGVD north of Elgin. This divide also separates surface drainage in the southernmost portion of the permit area from the surface drainage in the remainder of the permit area, which flows eastward to the Brazos River.

In contrast to the thin, red, sandy and clayey soils commonly occurring in the Interior Coastal Plain physiographic subprovince, the soils in the Blackland Prairies physiographic subprovince generally weather to deep, organically enriched, fertile clays. Additional information regarding soil resources is presented in Section 3.3, Soils. Their hydrologic characteristics are further discussed below in Section 3.2.4, Surface Water. The project area occurs within the Prairie and Lakes ecoregion, which includes the Oak Woods and Prairies and the Blackland Prairies (TPWD 1996, 2000a). Additional information on the vegetation types within this ecoregion is presented in Section 3.4, Vegetation. These vegetation types are interspersed with wetlands and riparian communities along drainages and in isolated depressions.

3.2.1.1 Hydrometeorology

The project area occurs in a Subtropical Humid climatic type (State Climatologist undated). The regional climatic characteristics are largely determined by the onshore flow of tropical maritime air from the Gulf of Mexico. Precipitation amounts are typically larger in late spring and fall. The wettest months generally are April, May, June, September, and October (Alcoa 2000 [Volume 5]). The driest months of the year typically are January, March, July, and August.



08110100 USGS Streamflow Gaging Station

Watershed Boundary

Source: Alcoa 2000 (Volume 5).

4 0 4 8
Scale in Miles

Three Oaks Mine

Figure 3.2-1

Regional Surface Waters

Average monthly total precipitation amounts for representative stations in the project region are shown in **Figure 3.2-2**. Data are shown for a period of record consistent with currently available evaporation data (1954 through 1998) (TWDB 2001b). Precipitation can vary widely between months and years. For example, the annual total precipitation on a regional basis has ranged from 13.44 inches in 1954 to 45.76 inches in 1957. Precipitation also varies between locations. Data for Elgin indicate that 34.38 inches fell in 1998, and 22.25 inches fell in 1999. In Lexington, 38.41 inches fell in 1998, and 18.81 inches fell in 1999 (Dittman 2001). Within the permit area, the average annual rainfall is approximately 33 inches.

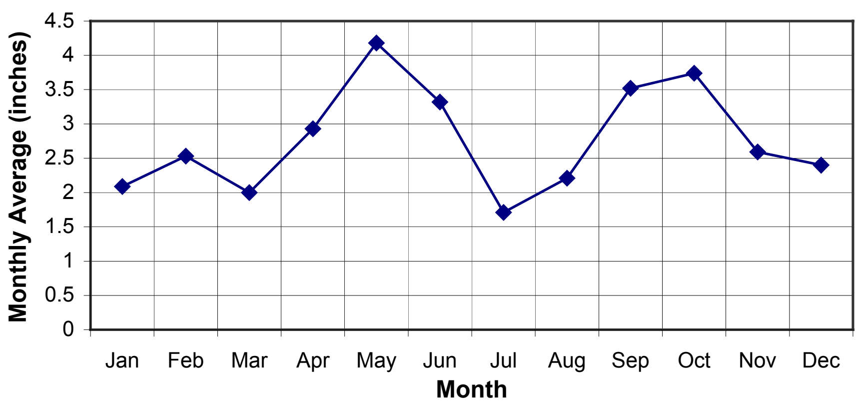


Figure 3.2-2 Average Regional Precipitation

Precipitation in the project vicinity primarily develops from the movement of maritime tropical air into Texas from the Gulf of Mexico and the Atlantic Ocean (Orten 1969). Squall-line thunderstorms often form as these air masses meet land-based frontal systems. Tropical cyclones (including hurricanes) also occur in summer and fall, most notably in August and September. Tornadoes most frequently occur in April, May, and June; however, they can occur in all seasons and often originate as tropical storms move inland in the late summer and early fall (Orten 1969).

The most severe storms generate precipitation over several days, creating moist watershed conditions. Significant flooding then may occur when more intense periods of precipitation fall within a day. In central Texas, recent examples of these severe and widespread floods occurred in early August 1978 and in late December 1991 through early January 1992. Both events resulted from a major meteorological condition (or a combination of them) as described above (Schroeder et al. 1987; Hejl et al. 1996; National Oceanographic and Atmospheric Administration [NOAA] 1995). Approximately 10 inches of rain fell in the project region during the December 1991 event (Hejl et al. 1996).

Both short-term droughts (3 months to a year) and extended droughts occur periodically in the region. The shorter droughts have the potential to create severe damage as a result of their timing in relation to seasonal water needs. The most severe extended drought occurred from 1950 through 1956 (Texas Water Resources Institute [TWRI] 1996). Additional extended severe droughts occurred in 1933 and 1934, and again in 1937 through 1939. Recently, severe drought conditions (generally lasting less than 1 year) have existed in the central Texas region during the late 1980s and intermittently since 1996 (TWRI 1996; AgNews 2000).

Over the consistent period of record from 1954 through 1998, the total free-water surface evaporation (e.g., from a lake) in the study area averaged approximately 52.8 inches per year. Evaporation ranged from a low of 44.5 inches in 1981 to a high of 65.4 inches in 1956 (TWDB 2001a). Still greater annual evaporation (72 inches in 1951) has been recorded by TWDB (Alcoa 2000 [Volume 5]). The highest monthly averages occur during the summer and early fall.

Due to soil infiltration and interception by topographic features (including lakes and ponds) and vegetation, only approximately 5 to 10 percent of the annual rainfall forms runoff and streamflow and less than 1 percent to more than 15 percent recharges groundwater (Alcoa 2000 [Volume 5]). These are general estimates and vary according to site-specific watershed factors; however, evapotranspiration forms the single largest source of consumption of rainfall in the region.

3.2.1.2 State and Local Water Resource Management

State and local water resource management organizations include the TNRCC, TWDB, river authorities, and regional water planning groups. Numerous other federal, state (including RRC), and local organizations have water resource roles, and these organizations frequently cooperate under memoranda of understanding. The USACE civil works mission within the state includes the development and operation of water supply and flood control facilities (reservoirs, levees, and flow conveyances), parks, and hydropower plants. Additional activities include streambank protection, fish and wildlife mitigation, environmental services for other government facilities, and a regulatory role with respect to the CWA as previously described in Chapter 2.0. The USACE facilities and programs are operated in coordination with other federal, state, and local water management organizations.

The two river authorities in the region include the Brazos River Authority and the LCRA. Both river authorities were created by the Texas Legislature, chiefly in response to severe floods in the early twentieth century. Both agencies have primary roles in water supply and water treatment (including wastewater). These authorities also monitor water quality, promote water conservation, and operate reservoirs and water distribution systems within their respective river basins. In addition, the LCRA also operates a system of electrical power plants.

The TWDB is primarily responsible for water resources planning and financial assistance for water development projects (Caroom 1997). TWDB also is responsible for developing the state water plan, and coordinates with numerous local and regional groups that also are involved in that effort. Financial assistance is granted to local government entities for water supply developments such as water treatment and storage projects, and water quality projects such as sewage treatment. TWDB often cooperates with the Bureau of Reclamation and the USACE in planning water resource development projects (Caroom 1997). TWDB has the authority to own storage rights in a reservoir, or own the reservoir outright, for purposes of optimally developing the State's water.

The TNRCC is the State's primary water rights and environmental regulatory authority. The agency was formed in 1993 and combines the former roles of the Texas Water Rights Commission, Texas Board of Water Engineers, Texas Water Pollution Board, Texas Air Control Board, Water Well Drillers Board, and Board of Irrigators (TNRCC 2001a). With regard to water resources issues in this EIS, TNRCC is responsible for administering water rights, enforcing state water quality regulations, and enforcing Section 401 of the CWA. The Texas Clean Rivers Program, administration of state water quality standards, and the State's 401 Certification Program are major water quality-related responsibilities of TNRCC. In addition, TNRCC administers the TPDES program. Municipal and many types of industrial discharges to surface waters of the state are regulated under this program. The water rights and water quality aspects of TNRCC programs relevant to the project are described in general below.

Water rights in Texas pertain to both surface water and groundwater; however, only surface water rights are administered through a system of recorded riparian and appropriated rights. Surface water is considered property of the State, whereas groundwater is considered the property of the owner of the surface estate. The “Rule of Capture” applies to groundwater resources in Texas. Significant aspects of this include (Caroom 1997):

- The owner of the land may pump unlimited quantities of water from under the land for beneficial use, regardless of the impact that action might have upon a neighbor's ability to obtain water on the neighbor’s land. Neither injunction nor damages prevent such action.

- Generally, surface water rights attach only after water has emerged from the ground. Prior to such emergence, the groundwater user can utilize any amount of water, regardless of the impact upon others.

- The surface estate owner may sell the groundwater captured below the surface estate for offsite use by a third party. The transport and use of groundwater at a distant location is permissible even though a majority may be lost in transit.

One exception to the general rule regarding groundwater is that underflow (that part of discharge in a watercourse that flows through sand and gravel deposits beneath the surface of the streambed) is considered to be property of the State. In addition, wanton and willful waste of groundwater resources, or malicious pumping with the purpose of injuring a neighbor, is prohibited, as is negligent pumping that causes subsidence of neighboring land. In addition to the common law restrictions, landowners in many areas are subject to regulations of local underground water conservation districts. Further regulation with respect to water rights is included in TAC, Title 16, Chapter 12, Subchapter K, Rule 12.352. This rule states that any person who conducts surface mining activities shall replace the water supply of an owner of interest in real property who obtains all or part of his or her supply of water for domestic, agricultural, industrial, or other legitimate use from an underground or surface source, where the water supply has been adversely impacted by contamination, diminution, or interruption proximately resulting from the surface mining activities.

Surface water in Texas is defined as water flowing in a defined watercourse (e.g., canyons, ravines, depressions, creeks, rivers, etc.) or stored in a pond, lake, or reservoir. Surface water is owned by the State and is available for use pursuant to the statutory appropriation process (Caroom 1997; TNRCC 2001b). A major exception to this applies to domestic and livestock usage. For these uses, reservoirs up to 200 acre-feet in capacity may be constructed on an individual's own property for domestic and livestock purposes. The courts have held that although only reservoir construction is directly addressed by the enabling legislation, the right to use the water also is implied.

Other than domestic and livestock uses, surface water rights in Texas are either riparian rights or appropriated rights. Riparian rights have priority over later appropriated rights and allow the owner of property adjacent to a watercourse to make reasonable use of water, including its impoundment, conveyance, and sale offsite. Riparian rights attach to land that was patented by the State between January 20, 1840, and July 1, 1895, and apply only to the normal flow of a stream, as opposed to storm or flood flow (Caroom 1997). As is common in other western states, appropriated rights in Texas authorize the diversion of a specific quantity of surface water at a specific point for an identified beneficial use on a particular tract of land. Fulfillment of an appropriated right to use water in any given year is based on seniority of the right. Since the late 1960s, the riparian rights in Texas have been defined, recorded, and adapted into the State's legal system of adjudicated rights (TWRI 1977; Caroom 1997; TNRCC 2001b).

TNRCC also is the primary water quality regulatory agency for the State of Texas. Its activities for the coal mining industry are coordinated with RRC. The CWA requires that all municipal and industrial point source dischargers obtain and comply with a National Pollutant Discharge Elimination System (NPDES) permit. (A ”point source” of potential pollutants into surface waters is a specific, identifiable location or conveyance where such materials may enter the environment). Storm water discharges from facilities such as coal mines also are regulated under this system. Nationally, the NPDES program is administered by the USEPA. Authority for the program in Texas (the TPDES program) was assumed by the State in September 1998, following approval by the USEPA. Wastewater and storm water discharges from coal mining facilities are regulated by TNRCC under the TPDES program and other state regulations. TPDES permits are developed to ensure that such discharges to receiving waters (e.g., a stream) are protective of human health and the environment. The permits establish discharge limits, monitoring and reporting requirements, and may stipulate measures to reduce or eliminate pollutant discharges to receiving waters (USEPA 1998). In Texas, mining wastewater discharges (e.g., treated sewage, domestic wastewater, groundwater discharged from mine dewatering or depressurization activities) are regulated primarily under the TPDES program. Wastewater and storm water management may be combined into one TPDES permit. Other state water quality regulations and the 401 Certification process administered by TNRCC also pertain. All permits for discharges from the proposed Three Oaks Mine would be subject to applicable regulatory review and approval processes through TNRCC in coordination with RRC.

Depressurization, dewatering, and storm water discharges from the Three Oaks Mine are proposed to be released into receiving waters in both the Colorado River watershed and the Brazos River watershed. Treated sewage and domestic wastewater are proposed for discharge into the Brazos River watershed (Alcoa 2001a). The proposed locations of the TPDES outfalls, or locations where the discharges would be released to receiving waters, are shown in Alcoa’s wastewater permit application (Alcoa 2001a). There are three proposed outfalls for discharges leaving the proposed site, two in the Big Sandy Creek drainage and one on Middle Yegua Creek (see **Figure 2-9**).

TNRCC regulations for the TPDES storm water program (General Permit TXR050000, Sector H) require the development and regulatory approval of a storm water pollution prevention plan. Such a plan necessarily addresses the quality of storm water discharges and their monitoring in coordination with other regulatory monitoring provisions. Other activities are to be defined as well, such as good housekeeping practices (procedures to avoid spills, litter, unnecessary waste, or accidents); the selection and implementation of BMPs to maintain water quality and control runoff, erosion, and sedimentation; an inspection and maintenance program for these practices; and a storm water pollution prevention organization/responsibility chart. Further description of activities and compliance under the TDPES program is presented in Chapter 2.0.

TNRCC regulations for the TPDES storm water program (General Permit TXR050000, Sector H) require the development and regulatory approval of a storm water pollution prevention plan. This plan would necessarily address storm water quality and discharge monitoring (in coordination with other regulatory monitoring provisions); good housekeeping practices; the selection and implementation of BMPs to maintain water quality and control runoff, erosion, and sedimentation; an inspection and maintenance program for these practices; and a storm water pollution prevention organization/responsibility chart.

The CWA Section 401 Certification Program (30 TAC 279), as administered by TNRCC, requires the selection and implementation of BMPs, and for Tier II projects (such as the Three Oaks Mine), requires analysis of alternatives that may satisfy the needs of the project in ways that do not adversely affect surface water in the state. Such alternatives and their costs and other criteria must then be compared. The Section 401 questionnaire and associated Alternatives Analysis Checklist are presented in Appendix B. Permits may be issued by the USACE under Section 404 of the CWA only if the TNRCC has certified under Section 401 of the CWA that the proposed discharge would comply with state water quality standards.

The probable hydrologic consequences (PHC) of a proposed operation are required to be analyzed by the proponent in accordance with 16 TAC 12.146, “Reclamation Plan: Protection of the Hydrologic Balance,” as administered by the RRC. These analyses are presented in the Three Oaks Mine RRC permit application (Alcoa 2001b [Volume 5]). The PHC analysis is largely based on available data from regional investigations and baseline data from the project-specific water resources inventory.

In order to design control features and to comply with permit requirements, Alcoa has conducted surface water and erosion modeling for the project using industry-standard tools, including HEC-1 and HEC-RAS (from the USACE Hydrologic Engineering Center), SEDCAD (originally from the University of Kentucky), and the RUSLE (from the U.S. Department of Agriculture [USDA] Agricultural Research Service). Flowmaster® (a proprietary open-channel hydraulics software package) and the Texas Hydraulic System Culvert Design software also were used.

3.2.2 Water Resource-related Regulations

Proposed mine construction, operation, and reclamation activities for the Three Oaks Mine would require water protection measures in accordance with applicable regulations and agency programs as discussed under State and Local Water Resource Management in Section 3.2.1, Hydrologic Setting. These requirements include:

- Section 404 of the CWA administered by USACE;
- RRC coal mining performance standards regarding protection of the hydrologic balance (16 TAC 12);
- Water quality regulations from TNRCC pertaining to Section 401 certification (30 TAC 279 and related guidelines);
- TPDES program (General Permit TXR050000, Sector H); and
- Water rights administration by TNRCC.

Compliance with these regulations and programs, and agency requirements for project reviews and approvals, would reduce the potential for impacts to water resources. The effectiveness of the proposed project activities for the Three Oaks Mine with respect to these regulatory programs was evaluated in the impact assessment, as applicable, as discussed below.

3.2.3 Groundwater

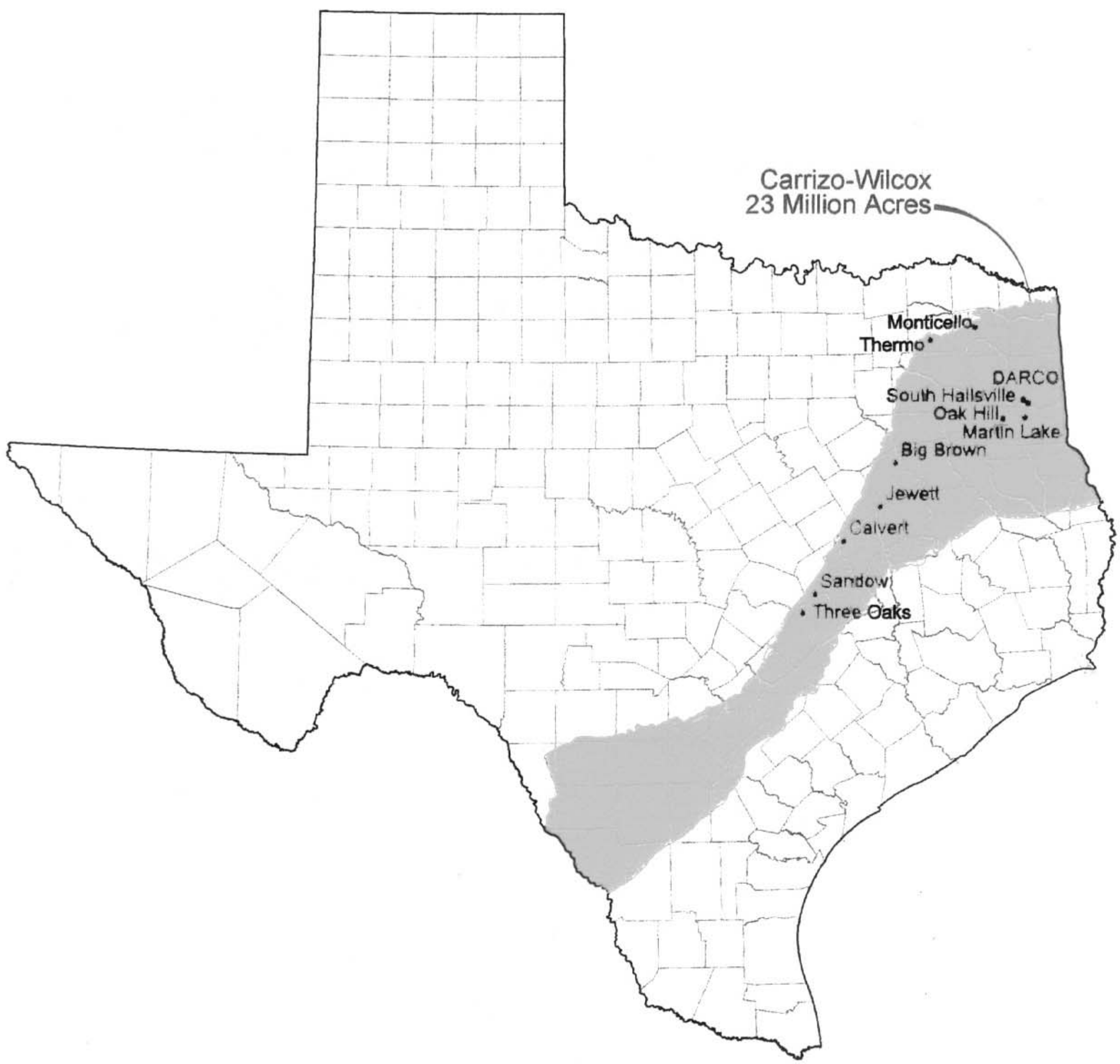
The groundwater study area includes the proposed Three Oaks Mine permit area and the surrounding area within the projected project-related 10-foot groundwater drawdown areas in the Calvert Bluff and Simsboro aquifers. The cumulative effects area includes the permit area and the surrounding area within the projected cumulative 10-foot groundwater drawdown areas in the Simsboro, Calvert Bluff, and Carrizo aquifers. Information relative to the regional and site-specific aquifers is presented below, with technical details presented in Appendix C.

3.2.3.1 Affected Environment

Regional Hydrogeology of the Carrizo-Wilcox Aquifer System

The Carrizo-Wilcox aquifer system is one of the major aquifer systems of east-central Texas (**Figure 3.2-3**), extending from the Rio Grande northeast across east-central Texas into Louisiana. The Carrizo-Wilcox aquifer system is not a single aquifer, but rather it consists of many aquifers hosted within Tertiary age sedimentary units that dip to the southeast (see Section 3.1, Geology). Sedimentary units containing mostly sand, such as the Simsboro and Carrizo Formations, host highly permeable aquifers that provide water for municipal and domestic use. Units rich in clay and silt, such as the Calvert Bluff and Hooper Formations, often contain lignite beds and generally have aquifers of low permeability that are restricted to sand lenses and channels within the clays, such as the Calvert Bluff and Hooper Formations. These restricted aquifers provide limited supplies of water for local municipal and agricultural use.

A discussion of the hydrogeology of Alcoa's existing Sandow Mine, which has been in operation since the 1950s, is included in this regional discussion as the mine is part of the existing regional environment. The mining techniques proposed for the Three Oaks Mine would be similar to those currently used at the Sandow Mine. The Sandow Mine and the Three Oaks Mine site have similar geologic and hydrologic



Source: Adapted from Thorkildson and Price 1991.

Three Oaks Mine

Figure 3.2-3

Carrizo-Wilcox Aquifer System in Texas

conditions. In addition, the available groundwater data for the existing Sandow Mine provides insight into the existing conditions and the potential groundwater impacts that may occur as a result of development of the proposed Three Oaks Mine. The existing and proposed mine sites are shown in **Figure 1-3**.

Regional Stratigraphy and Structure. The generalized stratigraphy of the regional Carrizo-Wilcox aquifer system is shown in **Table 3.2-1**. In east-central Texas, the main stratigraphic units of the aquifer are the Hooper, Simsboro, Calvert Bluff, and Carrizo Formations. The Hooper, Simsboro, and Calvert Bluff Formations are often grouped as the Wilcox stratigraphic group. The Carrizo-Wilcox sedimentary assemblage represents a period of Teritary age deltaic deposition in the Gulf Coast region of east-central Texas. Sand units (Simsboro and Carrizo Formations) alternate with deltaic clays and silts rich in organic matter that were deposited in large swamps between major river channels. These organic-rich swamps became the lignite seams and beds that comprise the lower part of the Calvert Bluff Formation; however, they also can be found as thin beds in the Simsboro and Hooper Formations. All stratigraphic units in the Carrizo-Wilcox system dip (slope) to the southeast at 100 to 200 feet per mile (1 to 2 degrees). This sloping leads to confined, or artesian, aquifers downdip where the units are covered by overlying confining formations and to unconfined, or water table, aquifers where these stratigraphic units outcrop on the surface in a northeast-trending band across east-central Texas.

The outcrops of the Carrizo Formation and the Wilcox Group sedimentary units extend between the Trinity and Colorado Rivers in east-central Texas and form a band of sedimentary rocks 10 to 26 miles wide (Thorkildsen and Price 1991). The average thickness of the Carrizo Formation is approximately 300 feet; however, the unit ranges up to 800 feet in thickness. The Wilcox Group has a cumulative thickness of up to 3,400 feet.

Within the Wilcox Group, the Calvert Bluff Formation averages 400 to 600 feet in thickness, with a maximum thickness of 2,130 feet; the Simsboro Formation averages 400 to 600 feet in thickness, with a maximum thickness of up to 880 feet; and the Hooper Formation is up to 1,380 feet thick. The surface geologic outcrops of the various formations are shown in **Figure 3.2-4**. Stratigraphic sections along strike and downdip over the regional extent of the Carrizo Formation and Wilcox Group are presented in the RRC Three Oaks Mine Permit Application (Alcoa 2000 [Volume 10]).

In the vicinity of the Sandow Mine, the Wilcox Group outcrop averages approximately 10 miles in width, with the vast majority of the Sandow Mine permit area occurring within the outcrop of the Calvert Bluff Formation. Underlying the permit area, the Hooper Formation, the lower of the three formations in the Wilcox Group, is up to approximately 500 feet thick and contains uneconomic lignite beds in the upper part of the formation. As a result, the formation is not mined, and due to its location below the Calvert Bluff and Simsboro Formations, it is not necessary to withdraw groundwater from this unit to accommodate mining. Overlying the Hooper is the Simsboro Formation (see **Table 3.2-1**). The Simsboro ranges in thickness from 75 to 700 feet and averages approximately 200 feet in thickness in the Sandow Mine area. The unit is a cross-bedded to massive sandstone. The Calvert Bluff Formation overlies the Simsboro and is approximately 1,000 feet thick in the Sandow Mine area. The unit is predominately silt and clay with locally interbedded sand zones. The lignite mined by Alcoa is in the lower one-third of this formation.

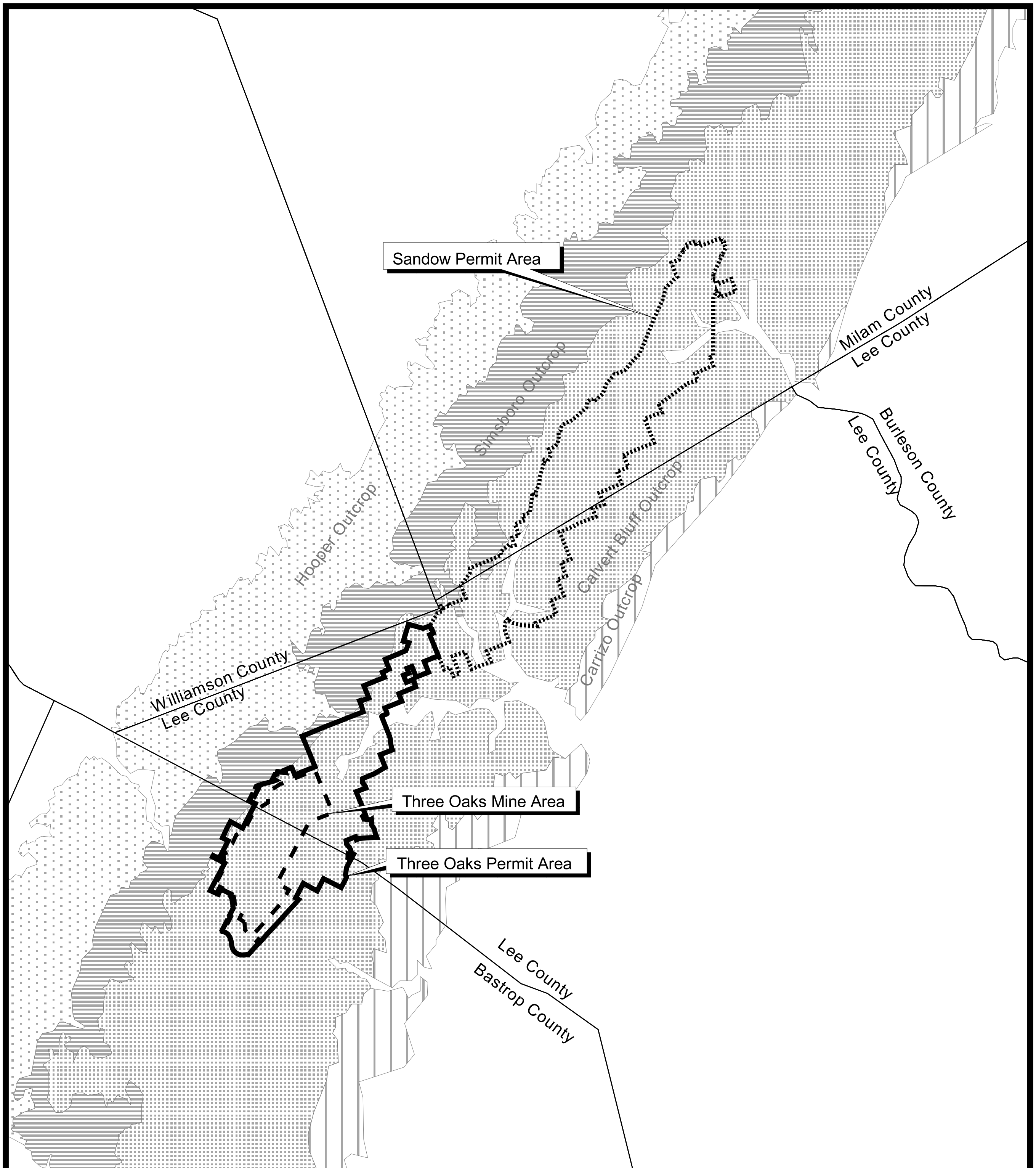
Table 3.2-1
Regional Geologic Units and Their Water-bearing Properties

<table>
<tr><th>System</th><th>Series</th><th>Group</th><th colspan="2">Geologic Unit</th><th colspan="2">Approximate Maximum Thickness (feet)</th><th colspan="2">Character of Unit</th><th colspan="2">Water-Bearing Properties[1,2]</th></tr>
<tr><td rowspan="4">Tertiary</td><td rowspan="4">Eocene</td><td>Claiborne</td><td colspan="2">Carrizo Formation</td><td colspan="2">880</td><td colspan="2">Fine to coarse sand. Light to dark gray, massive, commonly cross-bedded with some thin beds of sandstone and clay.</td><td colspan="2">Yields small to large quantities of fresh to slightly saline water.</td></tr>
<tr><td rowspan="3">Wilcox</td><td rowspan="3">Wilcox Undifferentiated Group</td><td>Calvert Bluff Formation</td><td rowspan="3">3,430</td><td>2,130</td><td rowspan="3">Fine to medium sand and sandstone. Light gray to moderate brown, commonly cross-bedded, lenticular, and interbedded with clay, sandy clay, some lenses of limestone, and thin beds of lignite. Wilcox Undifferentiated is a term generally used in referring to that part of the Wilcox group south of the Colorado River and north of the Trinity River. However, the same term is applied to those sediments between the Trinity and Colorado Rivers where data are not sufficient to make a more refined aquifer assignment.</td><td>Fine to course lenticular sand and sandstone. Light gray to pale brown, cross-bedded, and argillaceous in some areas, interbedded with various amounts of mudstone, ironstone concretions, and discontinuous beds of lignite.</td><td rowspan="3">Yields small to large quantities of fresh to slightly saline water.</td><td>Yields small to moderate quantities of fresh to slightly saline water.</td></tr>
<tr><td>Simsboro Formation</td><td>880</td><td>Fine to coarse light gray sand composed dominantly of quartz. Sand is massive and cross-bedded, containing relatively small amounts of clay, mudstone, and mudstone conglomerate.</td><td>Yields small to large quantities of fresh to slightly saline water.</td></tr>
<tr><td>Hooper Formation</td><td>1,380</td><td>Dominantly mudstone with various amounts of light gray to medium brown sandstone, lignite, and ironstone concretions. Sandstone is fine to medium grained, cross-bedded, and argillaceous in the lower part of the formation. Lignite forms thin, discontinuous beds in the upper part of the formation.</td><td>Yields small to moderate quantities of fresh to slightly saline water.</td></tr>
</table>

[1]Yields of wells in gpm:
Small = less than 100 gpm
Moderate = 100 – 1,000 gpm
Large = more than 1,000 gpm

[2]Quality of water in parts per million (ppm) dissolved solids:
Fresh = less than 1,000 ppm
Slightly saline = 1,000 – 3,000 ppm
Moderately saline = 3,000 – 10,000 ppm
Very saline = 10,000 – 35,000 ppm

Source: Thorkildson and Price 1991.



Outcrops
- Hooper
- Simsboro
- Calvert Bluff
- Carrizo

N

0 1 2 Miles

Source: Bureau of Economic Geology, University of Austin at Texas, Geologic Atlas of Texas, Austin Sheet, with slight modifications by R.W. Harden & Associates, Inc. near Three Oaks Mine area.

Three Oaks Mine

Figure 3.2-4

Outcrop Map of the Carrizo-Wilcox Aquifer System

7/18/02

Structurally, the southeast dipping sedimentary units of the Carrizo Formation and Wilcox Group are frequently offset by post-depositional normal faults that trend in a northeasterly direction (**Figure 3.1-6**). In the region around Paige, Texas, these normal faults are associated with a buried basin structure and the faults are grouped together and referred to as the Luling-Mexia-Talco Fault Zone (**Figure 3.1-2**). These faults have low permeability and generally act as barriers to the horizontal flow of groundwater in the aquifers. In the Sandow Mine area, normal faults are common. These faults have average vertical displacements of 50 to 100 feet, resulting in offset of the lignite units, and are generally impermeable to horizontal groundwater flow.

Groundwater Hydrology and Hydraulic Properties of the Aquifers. All groundwater in the Carrizo-Wilcox aquifer system is under either unconfined (water table) or confined (artesian) conditions. Downdip to the southeast of the outcrop areas, groundwater in the aquifers is under artesian conditions due to the overlying, confining stratigraphic units. Here the water levels rise in wells under pressure to their potentiometric surface (level to which the water will rise in the well casing due to the pressure in the aquifer) and in some cases may actually flow out on to the surface. Pumping water from an artesian aquifer will lower the potentiometric surface of the aquifer. Most of the aquifers of the Carrizo-Wilcox aquifer system in east-central Texas are under artesian conditions. Water table conditions in these aquifers only exist in areas along the aquifer outcrops (**Figure 3.2-4** and **Tables C-1** through **C-4**). Under water table conditions, the groundwater is under atmospheric pressure and will exist in a well at the level of saturation in the aquifer. As a result, water levels fluctuate in response to changes in the volume of water stored in the aquifer.

The principal aquifer in the Sandow Mine area is the Simsboro aquifer. The Calvert Bluff aquifer contains water in the sand channels and in sand-rich units; however, it is not a true aquifer. The Calvert Bluff is a formation that is predominately clay and silt with local sand channels and discontinuous sand-rich units. As the sand units within the Calvert Bluff often contain sufficient groundwater for local municipal and agricultural uses, the Calvert Bluff is treated as an aquifer in the hydrostratigraphy of east-central Texas. Groundwater elevations in the sand units of the Calvert Bluff in the Sandow Mine area range from 342 to 460 feet NGVD. The Carrizo aquifer begins approximately 3 miles southeast of the Sandow Mine permit area in the outcrop of the Carrizo Formation. Groundwater elevations in the Carrizo aquifer range from 321 to 389 feet NGVD in the Sandow Mine area. **Figure C-1** in Appendix C presents a simplified hydrogeologic section of the Sandow Mine area along the downdip direction (southeasterly).

Recharge and Groundwater Movement. Recharge or replenishment of groundwater in the Carrizo-Wilcox aquifer system comes mainly from precipitation and seepage from lakes and streams in the aquifer outcrop areas (see **Figure 3.2-4** for the outcrop area of the aquifers). The major controlling factors for aquifer recharge are the amount of annual precipitation, topography, vegetation, and the depth to the water level in aquifers in the outcrop area. Some minor recharge to the lower aquifers in the system may come from interformational leakage. This amount of leakage based recharge is considered to be minimal and is difficult to quantify (Thorkildsen and Price 1991). Recharge to the Carrizo-Wilcox aquifer system has been estimated at approximately 1 inch per year, or 2.7 percent of average annual precipitation across all of the formations (Thorkildsen and Price 1991). Recharge rates can vary between 1.0 and 5.0 percent. Since the aquifers of the Carrizo-Wilcox system are fully saturated except in areas of pumpage, recharge to the aquifers is low, and much of the potential recharge to the aquifers is lost to surface seepage and evapotranspiration. In areas of pumpage within or near the aquifer outcrop areas, recharge increases to approximately 5.0 percent (Thorkildsen and Price 1991).

RWHA (1999) estimated recharge for the Simsboro aquifer at approximately 2.5 inches per year in the Sandow Mine area to the west of the active mining along the outcrop of the Simsboro Formation. Recharge to the Calvert Bluff aquifer is estimated to be less than 1.0 inch per year at present.

Recharge that is not rejected in the outcrop moves downdip to the southeast from the aquifer recharge areas. Groundwater in the water table portions of the aquifers (the outcrop areas) also moves from areas of high elevation to areas of lower elevation, forming local groundwater flow lines and resulting in local seeps and springs in low areas during and after periods of heavy rainfall. Rates of groundwater movement in the Carrizo-Wilcox aquifer system are highly variable and depend on the hydraulic properties of the sands and clays. Laterally extensive sand zones have the highest rates of groundwater movement; zones that are predominately clay have the lowest. Groundwater flow rates in the laterally extensive sand zones range from 10 feet to 100 feet per year (Thorkildsen and Price 1991). Sedimentary units that are primarily sand, such as the Carrizo and the Simsboro Formations, have the highest groundwater flow rates. Discharge from the aquifers is to rivers and springs, interformational leakage, evapotranspiration, and to domestic and municipal wells. Generalized groundwater levels for the composite Carrizo-Wilcox aquifer system are shown in **Figure C-2** in Appendix C. These composite groundwater levels represent an average of the groundwater elevations in the Simsboro, Calvert Bluff, and Carrizo aquifers of the Carrizo-Wilcox system. As such, the groundwater elevations in **Figure C-2** represent a regional composite "average" for the entire Carrizo-Wilcox system rather than specific groundwater elevations of any individual aquifer within that system.

In the vicinity of the Sandow Mine, groundwater flow in the Simsboro aquifer is toward the mine's depressurization wells, which are currently pumping approximately 35,000 acre-feet per year (22,000 gpm) of groundwater (RWHA 2002b). **Figure C-3** in Appendix C presents the current groundwater levels in the Simsboro aquifer at the Sandow Mine. Drawdown in the Calvert Bluff aquifer as a result of dewatering for Sandow Mine operations is localized near the mine pits. The mine dewatering wells pump approximately 700 gpm on average from sand channels and sandy units in the Calvert Bluff. Drawdown is limited to the sand units within the lignite zones in the lower one-third of the formation (RWHA 1999). As a result, there is no well-developed drawdown cone in the Calvert Bluff aquifer associated with the Sandow Mine operation.

Hydraulic Properties of the Aquifers. The four principal hydraulic properties of an aquifer that determine the rate of groundwater movement, the amount of water stored in an aquifer, and the amount of water that can be withdrawn from an aquifer are the hydraulic conductivity, transmissivity, porosity, and storage coefficient. The hydraulic properties of the Carrizo-Wilcox aquifer system in east-central Texas are described in Appendix C and are shown in **Table C-1**.

Groundwater Quality in the Carrizo-Wilcox Aquifers. Groundwater in the major water storing sands of the Carrizo-Wilcox aquifer system is mainly fresh to slightly alkaline (pH of 7.0 to 8.0 standard units) and useable for domestic consumption and irrigation. Most wells have total dissolved solids (TDS) of less than 1,000 milligram per liter (mg/l), and the majority of the wells have TDS levels below 500 mg/l. **Table C-2** in Appendix C provides the mean and range of various constituents in the groundwater of the Carrizo-Wilcox aquifer system of east-central Texas (Thorkildsen and Price 1991). The groundwater is generally dominated by calcium and sodium bicarbonate, with sulfate less than bicarbonate and chloride ranging from 50 to 200 mg/l. The sodium adsorption ratio (SAR) is generally below 10; this parameter is important for irrigation use of groundwater, and values below 10 are desired. Iron generally is in the range of 2.0 to 4.0 mg/l. The iron content of the groundwater indicates that the water may need to be treated prior to domestic use. The chemical quality of groundwater in wells in the outcrop zone of the Carrizo-Wilcox system in east-central Texas as sampled by Thorkildsen and Price (Thorkildsen and Price 1991) is presented in **Figure C-4** in Appendix C. **Figure C-4** and **Table C-2** generally represent the best water quality in the Carrizo-Wilcox aquifer system, as these wells generally produce from the sand zones. Water quality in silts, clays, and siltier sand zones have poorer water quality, with TDS often exceeding 5,000 mg/l.

Groundwater Supply in the Carrizo-Wilcox Aquifer. Groundwater in the Carrizo-Wilcox aquifer system is currently used for municipal, industrial, domestic, and agricultural purposes. Total central Texas usage in 1980 was 40,830 acre-feet (Thorkildsen and Price 1991). Of this amount, 33,854 acre-feet (83 percent) was for municipal use in cities and towns including Bastrop, Bryan-College Station, Elgin, Rockdale, and others. Bryan-College Station accounted for 19,367 acre-feet of pumpage, which was 57 percent of the total amount for the region. Industrial use accounted for 1,751 acre-feet (4 percent) of the total usage. Agricultural use for irrigation accounted for 2,085 (5 percent) of the total usage. Local municipal use comprised the remainder of the groundwater pumped in 1980. Groundwater usage for 1980 is summarized in **Table 3.2-2**.

Hydrogeology of the Three Oaks Mine Area

The proposed Three Oaks Mine lies to the southwest of Alcoa's existing Sandow Mine, within the Texas lignite belt, as shown in **Figure 2-2**. The geology and groundwater conditions in the Three Oaks Mine area are similar to those throughout the Carrizo-Wilcox aquifer system, including the Sandow Mine area, as discussed above.

Stratigraphy and Structure. The geology of the proposed Three Oaks Mine area is shown in **Figures 3.1-6** and **3.1-7** and discussed in more detail in Section 3.1, Geology. Hydrostratigraphic units in the permit area include the Hooper, Simsboro, and Calvert Bluff Formations. The Carrizo Formation is not present within the permit area; however, it outcrops approximately 2 to 3 miles southeast of the permit area (**Figure 3.2-4**). The other hydrostratigraphic units are present in the permit area in the subsurface, with the Simsboro and Calvert Bluff Formations also outcroping in the permit area (**Figure 3.2-4**). The stratigraphic succession in the permit area is much the same as throughout the Wilcox Undifferentiated Group, as summarized in **Table 3.2-1**.

The Carrizo is a major sand unit in the Carrizo-Wilcox aquifer system and consists mainly of clean beach and littoral sands. The outcrop of the Carrizo Formation lies approximately 2 to 3 miles southeast of the permit area (**Figure 3.2-4**). In this location, the unit has an outcrop width of 1.5 to 2.5 miles. The soils overlying the Carrizo are soft, and this unit is subject to many local depressions and seeps and springs, especially during the rainy season. The Carrizo is an important water-supply aquifer farther to the southeast in east-central Texas.

Table 3.2-2
Estimated 1980 Groundwater Pumpage from the Carrizo-Wilcox Aquifer System

County	Pumpage (acre-feet)				
	Municipal	Industrial	Irrigation	Municipal and Livestock	Total
Bastrop	3,549	76	665	369	4,659
Brazos	19,367	0	0	2	19,369
Burleson	783	0	0	28	811
Caldwell	1,719	1	70	94	1,884
Falls	0	0	0	9	9
Fayette	0	0	0	0	0
Freestone	1,430	119	0	483	2,032
Gonzales	118	0	475	442	1,035
Lee	725	0	125	368	1,218
Leon	928	161	0	389	1,478
Limestone	0	398	0	52	450
Madison	0	0	0	43	43
Milam	2,341	968	0	361	3,670
Navarro	0	0	0	30	30
Robertson	2,894	28	750	461	4,133
Williamson	0	0	0	9	9
Total	**33,854**	**1,751**	**2,085**	**3,140**	**40,830**

Source: Thorkildsen and Price 1991.

The Calvert Bluff is often considered an aquifer because it can supply groundwater for local municipal and agricultural use. However, the Calvert Bluff is a sedimentary unit dominated by fluvial sand channels and interchannel clays and silts. The sand channels are discontinuous; however, they are often large enough to supply groundwater for local use. The clays and silts are generally of low permeability, and although they may be saturated with water, the yield of wells is generally too low and of too poor a quality for domestic use. The Calvert Bluff averages approximately 900 feet in thickness in the permit area and ranges in thickness from approximately 500 feet to nearly 1,800 feet (Alcoa 2000 [Volume 4]). The formation hosts lignite seams in the lower third of the unit. The outcrop width of this unit in the permit area is approximately 5 miles (**Figure 3.2-4**).

The Simsboro Formation lies below the Calvert Bluff and is the major water-bearing unit in the permit area. The Simsboro averages approximately 400 feet in thickness and ranges in thickness from 300 to 700 feet. This unit is a major permeable sand unit in east-central Texas and provides both domestic and municipal water throughout most of the extent of the Carrizo-Wilcox aquifer system. In the permit area, this unit consists mainly of clean massive to cross-bedded sands and silty sands. The outcrop width of the unit in the permit area is approximately 1.5 to 2.0 miles and is located just to the west of the mine area (**Figure 3.2-4**). The Simsboro is separated from the lowest mineable seam in the Calvert Bluff by a thick clay unit of very low permeability. This clay unit averages 60 feet in thickness (Alcoa 2000 [Volume 4]).

The Hooper Formation lies below the Simsboro and outcrops to the west-northwest of the permit area (**Figure 3.2-4**). This unit is predominately a mudstone with sandstone, ironstone, and thin, uneconomic lignite beds. The Hooper Formation would not be mined or dewatered in association with the Three Oaks Mine.

The only important structural features within and adjacent to the permit area are inactive normal faults (Jackson and Wilson 1982) that offset the stratigraphic section by a few hundred feet. These faults are post-depositional and usually offset the stratigraphic units down toward the southeast. They penetrate the entire stratigraphic section. The faults have very low permeability, and where flow patterns are not modified by pumping, groundwater usually mounds up against the faults as it flows to the southeast in the Simsboro, Calvert Bluff, and Carrizo Formations.

Groundwater Hydrology and Aquifer Properties. The principal aquifer underlying the permit area is the Simsboro aquifer (**Figure 3.1-7**). The Calvert Bluff contains local aquifer units in the major sand channels; however, it is not a major water supply aquifer. As described above, the Carrizo aquifer occurs approximately 2 to 3 miles southeast of the permit area and is the other major aquifer in the study area. The general groundwater level elevations in the Simsboro aquifer are shown in **Figure C-6** in Appendix C. The Calvert Bluff (upper, 200 lignite zone, and 800 lignite zone) groundwater level elevations are shown in **Figures C-7, C-8,** and **C-9**, respectively, in Appendix C. Groundwater elevations in the Carrizo aquifer (**Figure C-10** in Appendix C) have been measured at only a few locations and range from approximately 320 to 580 feet NGVD. The vertical relationship of groundwater in these three aquifers, as measured south/southeast of the permit area, is shown in **Figure C-11** in Appendix C. **Figure 3.1-7** presents a simplified hydrogeologic cross-section aligned in a southeasterly direction and portraying the downdip stratigraphic and hydrostratigrahic relationships between the Simsboro, Calvert Bluff, and Carrizo aquifers. The Hooper aquifer lies below the Simsboro and is not hydraulically connected to it. As a result, the Hooper aquifer is not discussed further in this section.

Hydraulic Properties and Groundwater Movement. The groundwater gradient in the Simsboro aquifer is to the southeast at approximately 0.0023 feet/feet. The range in groundwater elevation is from approximately 540 feet NGVD in the area of the Simsboro outcrop area west of the Three Oaks Mine to 325 feet NGVD near Paige, Texas. The average porosity of the Simsboro sands is approximately 20 percent. The results of aquifer tests (Alcoa 2000 [Volume 4]) in the Three Oaks Mine area are presented in **Table C-3** in Appendix C.

The Calvert Bluff aquifer does not have a consistent mappable water table or potentiometric surface (**Figures C-7, C-8,** and **C-9** in Appendix C). Groundwater levels range from 420 to 480 feet NGVD in the upper Calvert Bluff Formation (approximately the upper 100 feet) in the permit area, including the outcrop of the formation, to values of 300 to 450 feet NGVD downgradient to the southeast near Paige, Texas. There is no consistent pattern to the measured water levels, as the groundwater is found mainly in the channel sand units. As a result, the groundwater levels presented in **Figures C-7, C-8,** and **C-9** are a generalized representation of groundwater levels in the sand units.

The Carrizo aquifer has not been studied in detail in the study area. The regional properties of the Carrizo aquifer are presented earlier in this section.

Recharge of the Aquifers. Recharge of the aquifers in the study area is mainly from precipitation in the outcrop zone. Recharge to the Simsboro and Carrizo aquifers can be 2 to 4 inches per year, depending on soil and vegetation conditions in the recharge area (Alcoa 2000 [Volume 4]). Recharge to the Calvert Bluff aquifer is very low due to the high clay content in the Calvert Bluff Formation and is estimated in the range of 0.5 inch per year or less (Alcoa 2000 [Volume 4]).

Interconnection Between Aquifers. The Simsboro aquifer generally is separated from the lowest Calvert Bluff sand lenses and mineable lignite seams by a clay zone averaging nearly 60 feet in thickness (Alcoa 2000 [Volume 4]). A long-term (9-day) pumping test and a multiwell pumping test (Alcoa 2000 [Volume 4]) showed that with 30 feet of drawdown in the Simsboro, there was no measurable change in water levels in the immediately adjacent Calvert Bluff. Any flow of water downward from the Calvert Bluff to the Simsboro would be very slow, and interconnection between major sands in the formations is believed to be non-existent.

The Calvert Bluff Formation is mainly a deltaic clay and silt sedimentary unit. The Calvert Bluff thus acts as a clay liner beneath the Carrizo aquifer. There is a general downward hydraulic gradient from the Carrizo to the Calvert Bluff; however, the low permeability of the Calvert Bluff clays prevents downward flow of water from the Carrizo. Only where the Carrizo overlies sandy areas of the Calvert Bluff would there be any substantial flow of water between the two aquifers.

Many normal faults penetrate the stratigraphic section in the permit area and to the southeast. These faults are generally impermeable and inhibit horizontal as well as vertical flow of groundwater in each aquifer. Pumping tests (Alcoa 2000 [Volume 4]) using monitor wells placed on both the upgradient and downgradient sides of normal faults showed that pumping on the upgradient side of a fault did not register any groundwater decline on the downgradient side of the Simsboro aquifer, substantiating the very low permeability of the faults. Vertical movement of groundwater along these faults would not be expected due to the clay gouge that often seals faults. This clay gouge is formed by the shearing action of the fault.

Groundwater Quality. Groundwater quality in areas immediately adjacent to and in the permit area varies and is dependent on the individual aquifer and whether the well is screened in sand or silt and clay. Groundwater samples taken in and adjacent to the permit area are presented in the RRC Three Oaks Mine Permit Application (Alcoa 2001b [Volume 2]).

For the Calvert Bluff aquifer, groundwater quality varies in the sand channels and the intervening deltaic clays and silts. Thus, groundwater in the Calvert Bluff is highly variable and can be somewhat acidic with high iron and sulfate, or can be near neutral and be calcium bicarbonate water. For the most part, however, groundwater in the Calvert Bluff is mineralized and generally not suitable for domestic use without treatment. Groundwater from the sand channels and from areas generally removed from the lignite beds can be suitable for irrigation and livestock use. Trace metals are low in groundwater from the Calvert Bluff, except for iron and manganese.

Groundwater in the Simsboro aquifer is mostly calcium bicarbonate water, generally of good quality, and suitable for human consumption. Groundwater in the Carrizo aquifer also is of good quality and suitable for domestic consumption. However, iron and manganese often can be above drinking water standards in the shallower portions of these formations.

Groundwater Supply and Demand. Current groundwater usage in the permit area is limited to municipal and agricultural use. An inventory of wells (Alcoa 2001b [Volume 2]) identified 68 wells within the permit area. Thirty-three of the wells were screened in the Calvert Bluff aquifer; most of these were not in use at the time of the inventory. Twenty-two of the wells were screened in the Simsboro aquifer and were used for domestic water supply. Most of the wells within the permit area are owned by Alcoa or City Public Service. The RRC Three Oaks Mine Permit Application (Alcoa 2001b [Volume 2]) contains a list of wells inventoried within and adjacent to the permit area.

Several public water supply systems are present within approximately 20 to 30 miles of the permit area boundary. These include water supply systems for the cities of Elgin, Bastrop, Lexington, Giddings, Smithville, and McDade, as well as systems controlled by the Aqua Water Supply Corporation (Alcoa 2000 [Volume 4]). Aqua Water Supply Corporation's 1998 annual water use was 5,759 acre-feet. The City of Giddings used 1,153 acre-feet. The City of Bastrop had an annual water use in 1998 of 1,114 acre-feet, and the City of Elgin used 969 acre-feet. The total groundwater pumpage reported for Lee County in 1997 was 4,112 acre-feet and that of Bastrop County was 8,468 acre-feet. Total groundwater usage for municipal and agricultural purposes in the permit area and in adjacent areas within Lee and Bastrop Counties was approximately 18,000 to 20,000 acre-feet in 1998. Studies by Dutton (1999) have shown that there is sufficient groundwater to meet these demands.

3.2.3.2 Environmental Consequences

<u>Proposed Action</u>

Groundwater Quantity Impacts.

<u>Numerical Groundwater Flow Modeling</u>. A nine layer three-dimensional groundwater flow model for the Three Oaks Mine was developed for Alcoa by RWHA (Alcoa 2000 [Volume 4]) to estimate the pumpage required for pit dewatering in the Calvert Bluff aquifer and to evaluate impacts from mine-related depressurization of the Simsboro aquifer. The model code used was the USGS version of MODFLOW (McDonald and Harbaugh 1988). Among other factors, the numerical model took into account recharge in the aquifer outcrop zones, evapotranspiration by plants, the effect of faults on groundwater flow, and the interconnection between aquifers. The placement of wells for dewatering and depressurization was based on Alcoa's best estimate of mine development over the 25-year life of the mine. Field studies of aquifer properties were conducted to provide input data for the model. The Carrizo and Simsboro aquifers are each represented by a layer in the model; the Calvert Bluff aquifer is represented by five layers to account for lignite horizons. The primary purpose of the model was to assist in predicting and designing dewatering and depressurization needs for the Three Oaks Mine and evaluating dewatering and depressurization impacts from the mine.

The USACE, USGS, and OSM evaluated the Three Oaks LOM groundwater model for its applicability in assessing potential environmental impacts within and near the project area. As the USACE's third-party environmental contractors, ENSR Corporation and HydroGeo, Inc. examined the model input data files, the grid design, the boundary conditions, and the model input parameters to ensure they were suitable for modeling environmental impacts within and adjacent to the proposed project area. In addition, the model was run to examine the calibration, the stability and convergence of the model, and the model's ability to replicate the results presented in the Alcoa Three Oaks Mine RRC permit application (Alcoa 2000 [Volume 4]). A model input parameter sensitivity evaluation was conducted for horizontal hydraulic conductivity, storage coefficients, vertical leakance for each layer, evapotranspiration, and recharge. These input parameters were varied in the model to determine the sensitivity of the model calibration to the input parameter and to determine the sensitivity of predicted model impacts to the input parameter. For the Three Oaks LOM Model, the model was found to be very sensitive to horizontal hydraulic conductivity and moderately sensitive to recharge; the model was not sensitive to the other input parameters. The results of the ENSR/HydroGeo evaluation are available in a report titled: *Review of the Three Oaks Life-of-Mine Groundwater Flow Model for Groundwater Analyses in the Three Oaks Mine EIS* (ENSR Corporation and HydroGeo, Inc. 2002a).

The USACE and OSM determined that the Three Oaks LOM Model is adequate for determining the environmental impacts associated with mine dewatering and depressurization. The USGS evaluated the Three Oaks LOM Model from the standpoint of its representation of the physical site conditions within and around the proposed Three Oaks Mine area. The USGS commented on specific aspects of the model design, particularly the design of the river cells, the use of evapotranspiration in the model, and the model's overall applicability to modeling groundwater drawdown impacts. The USACE has provided additional information in response to the USGS comments. Letters from the OSM and the USGS presenting their peer reviews of the Three Oaks LOM Model are on file with the Fort Worth District of the USACE.

Impacts To Groundwater Levels. Based on the modeling results, dewatering operations in the lower Calvert Bluff aquifer and depressurization operations in the Simsboro aquifer would affect groundwater levels in both aquifers over the life of the mine and for approximately 100 years after the cessation of mining. This section discusses these two proposed groundwater withdrawal activities and their potential impacts on groundwater quantity in the project area.

Calvert Bluff Aquifer Dewatering. Dewatering wells would be installed incrementally over the life of the mine in advance of pit development. The wells would be placed peripherally to the active pit area to partially remove groundwater from water-bearing sand lenses that lie above the lignite seams in the Calvert Bluff Formation. These sand lenses are interbedded with clay and lignite zones of very low permeability. As a result, the Calvert Bluff Formation does not contain a single regional aquifer; rather, it has saturated clay zones and sand lenses with the sand lenses being locally permeable and capable of yielding groundwater to wells. Removal of groundwater from these sand lenses would reduce the amount of groundwater seeping into the pit and would serve to stabilize the spoil and highwall for safety reasons and allow efficient operations. Estimated dewatering pumping rates would range from 290 acre-feet per year (180 gpm) (Alcoa 2001c [Volume 3]) to 1,349 acre-feet per year (1,836 gpm) (RWHA 2002c).

Based on data from existing monitoring wells in the area of the proposed Three Oaks Mine, current groundwater levels in the Calvert Bluff Formation range from 420 to 600 feet NGVD (see **Table 3.2-3** and **Figures C-7, C-8,** and **C-9** in Appendix C). The upper Calvert Bluff has groundwater levels ranging from

Table 3.2-3
Estimated Groundwater Drawdown as a Result of Mine Pumpage[1]

Year/Location	Existing Groundwater Levels and Projected Drawdown				
	Carrizo Aquifer	Upper Calvert Bluff[2]	Calvert Bluff 200 Zone[2]	Calvert Bluff 800 Zone[2]	Simsboro Aquifer
Existing groundwater level (year 2000)	460 to 580 feet NGVD in outcrop area southeast of Three Oaks Mine (**Figure C-10**)	420 to 480 feet NGVD in Three Oaks Mine area (**Figure C-7**)	420 to 520 feet NGVD in Three Oaks Mine area (**Figure C-8**)	440 to 600 feet NGVD in Three Oaks Mine area (**Figure C-9**)	400 to 540 feet NGVD regionally; 460 to 540 feet NGVD in outcrop area west of Three Oaks Mine (**Figure C-6**)
Projected Drawdown in Year 2030					
Permit area	Not present	No drawdown	100 to 200 feet of drawdown (**Figure 3.2-5**)	20 to 100 feet of drawdown (**Figure 3.2-6**)	100 to 200 feet of drawdown (**Figure 3.2-8**)
Outcrop area	No drawdown[3]	No drawdown	Does not outcrop	Does not outcrop	10 to 50 feet of drawdown (**Figure 3.2-8**)
Extent of 10-foot drawdown	No drawdown[3]	No drawdown	12 to 13 miles from permit boundary (**Figure 3.2-5**)	5 miles from permit boundary (**Figure 3.2-6**)	10 to 16 miles from permit boundary near Colorado River (**Figure 3.2-8**)

[1]Modeled drawdown results based on Three Oaks Mine dewatering and depressurization pumpage.
[2]Modeled drawdown is representative of drawdown in the Calvert Bluff sand units.
[3]Based on the model results, there would be no drawdown in the Carrizo aquifer as a result of mine-related pumpage.

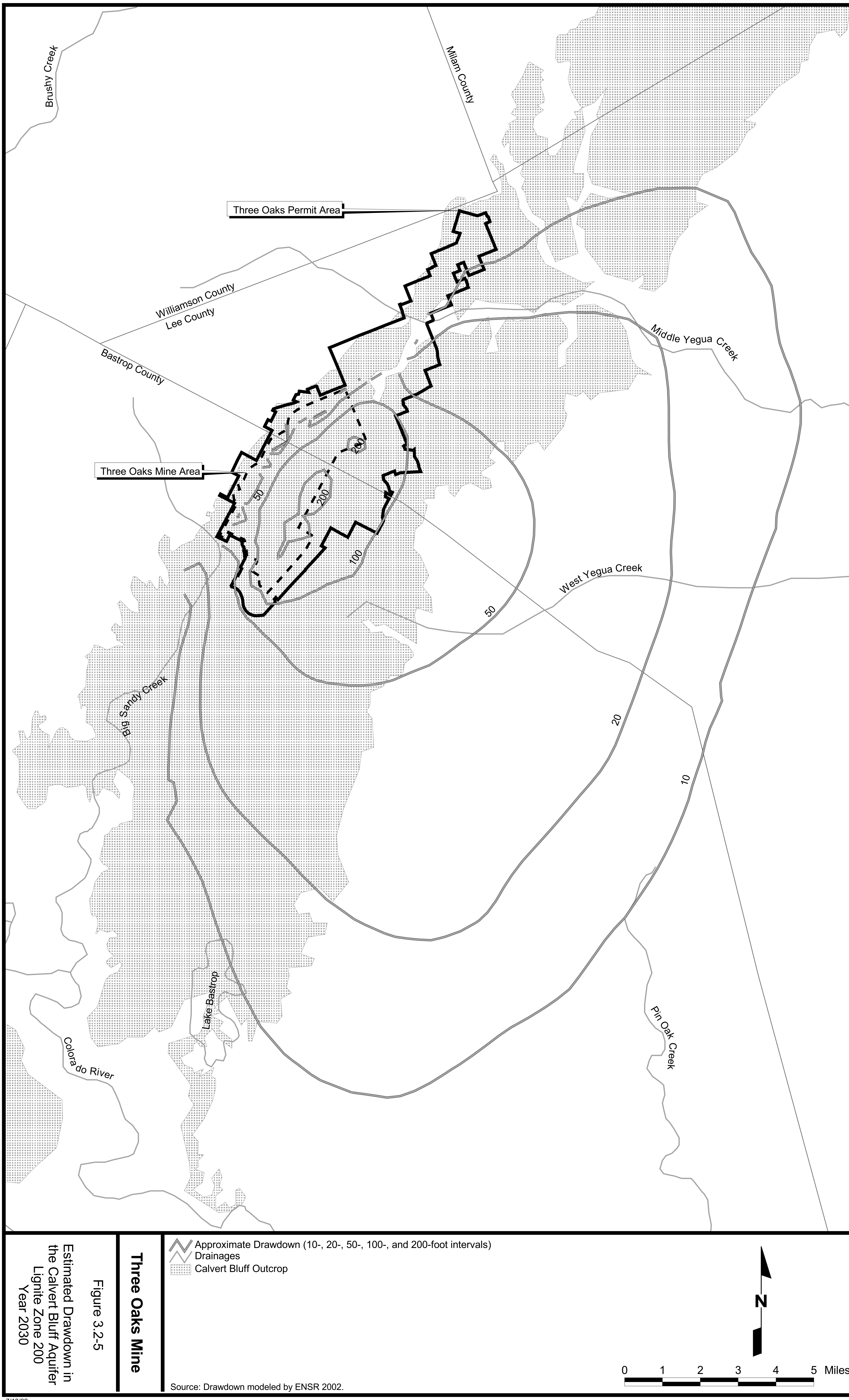
420 to 480 feet NGVD. The 200 lignite zone in the Calvert Bluff has similar groundwater levels; however, the 800 lignite zone has groundwater levels ranging from 440 to 600 feet NGVD. In the proposed mine area, groundwater in the Calvert Bluff occurs at approximately 20 to 40 feet below ground surface.

The Calvert Bluff 200 through 800 lignite zones would be dewatered at an average rate of approximately 882 acre-feet per year (547 gpm) over the estimated 25-year life of the mine. Drawdown of the potentiometric surface in the Calvert Bluff would be limited to the lower third of the formation as: 1) that is where the dewatering wells would be screened, and 2) clay zones with low permeability separate the water-bearing sand lenses, resulting in a general lack of connection between the lenses. Modeling results of groundwater drawdown in the Calvert Bluff aquifer are shown in **Figures 3.2-5** and **3.2-6** and summarized in **Table 3.2-3**. Based on the modeling results, there would be no drawdown in the upper Calvert Bluff Formation as a result of dewatering activities at the proposed Three Oaks Mine. For year 2030, which is the approximate end of mining for the Three Oaks Mine, drawdown in the 200 lignite zone of the Calvert Bluff Formation is projected to be approximately 100 to 200 feet in the permit area. The 10-foot drawdown area would extend approximately 12 to 13 miles from the permit boundary. For the 800 lignite zone, the drawdown in the permit area in year 2030 would be approximately 20 to 100 feet, and the 10-foot drawdown area would extend approximately 1 mile from the permit boundary. Calvert Bluff groundwater levels in the area of the proposed Three Oaks Mine would begin to recover following the completion of mining.

Pumping of the dewatering wells would result in a direct impact to water levels and, thus, the water quantity for private municipal or agricultural wells that are screened in the lower third of the Calvert Bluff Formation. The degree of impact to these wells would depend on the location of the wells relative to groundwater drawdown in the sand lenses in the lower third of the Calvert Bluff. The cross-section presented in **Figure 3.2-7** illustrates the relationship between drawdown in the various lignite zones of the Calvert Bluff due to dewatering and the potential drawdown in private wells screened within the Calvert Bluff Formation. Wells located within the 20-foot or greater drawdown area for the 200 through 800 lignite zones of the Three Oaks Mine may experience a noticeable decline in water levels; these wells and pumping equipment potentially would need to be modified or replaced in order to continue supplying water at their current rate. Alcoa’s proposed groundwater monitoring plan is described in **Table 2-15**. Additional mitigation may be appropriate to provide baseline and operational monitoring data for evaluation of potential mine-related impacts to existing wells within the modeled LOM 20-foot drawdown area of the Calvert Bluff aquifer (see **Figures 3.2-5** and **3.2-6**) (see mitigation measures GW-1 and GW-2 in Section 3.2.3.4, Monitoring and Mitigation). If mine-related impacts to private domestic, agricultural, or municipal wells are identified, Alcoa would mitigate the impact as required by the RRC.

Lignite mining into the lower third of the Calvert Bluff Formation, and concurrent backfill of previously excavated pits with mine spoil as the mine pit advances, would result in a permanent alteration of the lithologic units in the Calvert Bluff Formation and a corresponding localized permanent change in aquifer properties within the mine pit area. It is anticipated that the mixture of clay and sand in the backfilled pits would have a lower horizontal permeability and potentially an increased vertical permeability (Alcoa 2000 [Volume 10]).

The Three Oaks Mine would affect approximately 5 percent of the total outcrop area of the Calvert Bluff Formation between the Colorado and Trinity Rivers. Recharge to the Calvert Bluff aquifer would come from

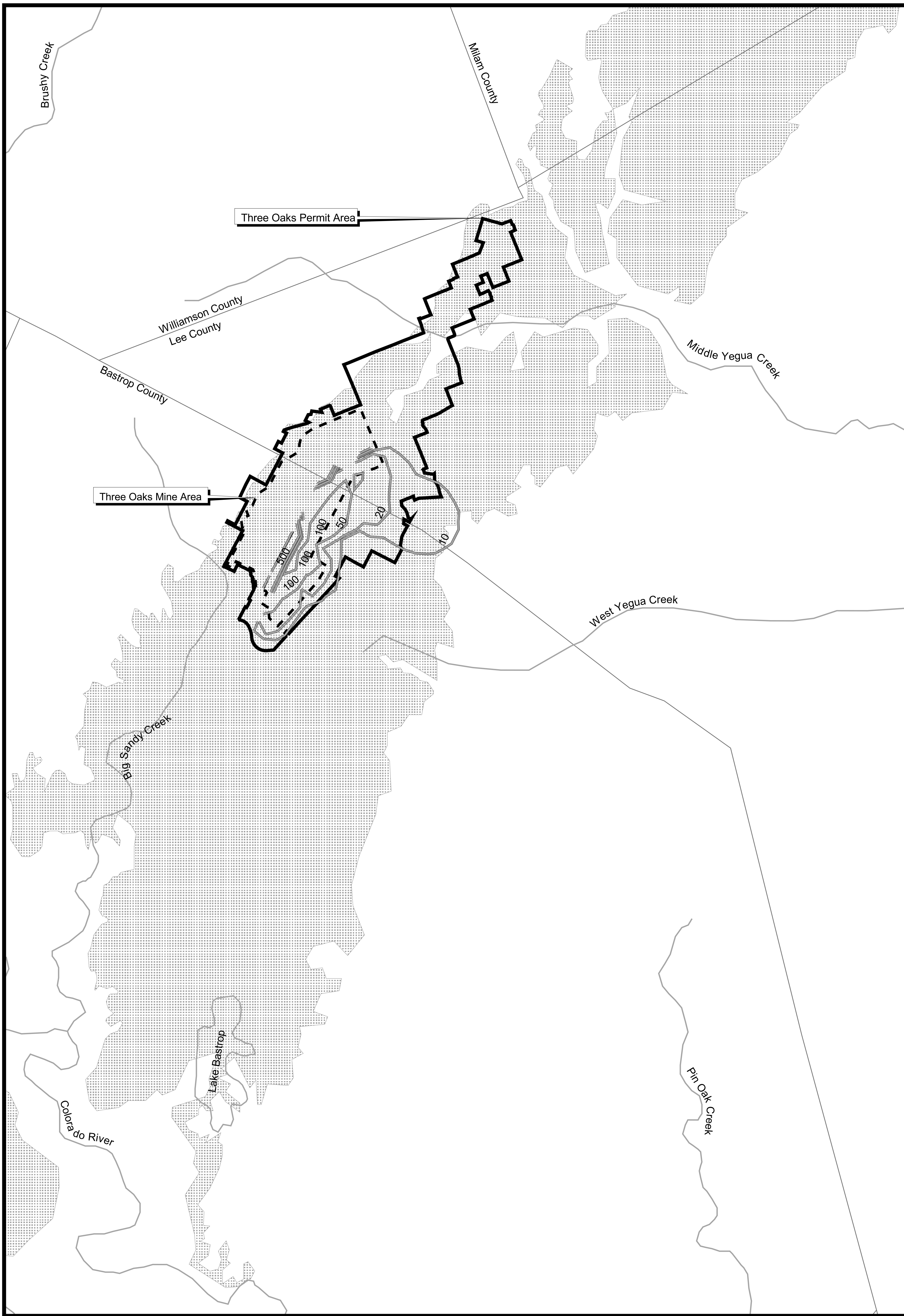


Source: Drawdown modeled by ENSR 2002.

Three Oaks Mine

Figure 3.2-5
Estimated Drawdown in the Calvert Bluff Aquifer
Lignite Zone 200
Year 2030

7/18/02



Three Oaks Mine

Figure 3.2-6
Estimated Drawdown in the Calvert Bluff Aquifer Lignite Zone 800 Year 2030

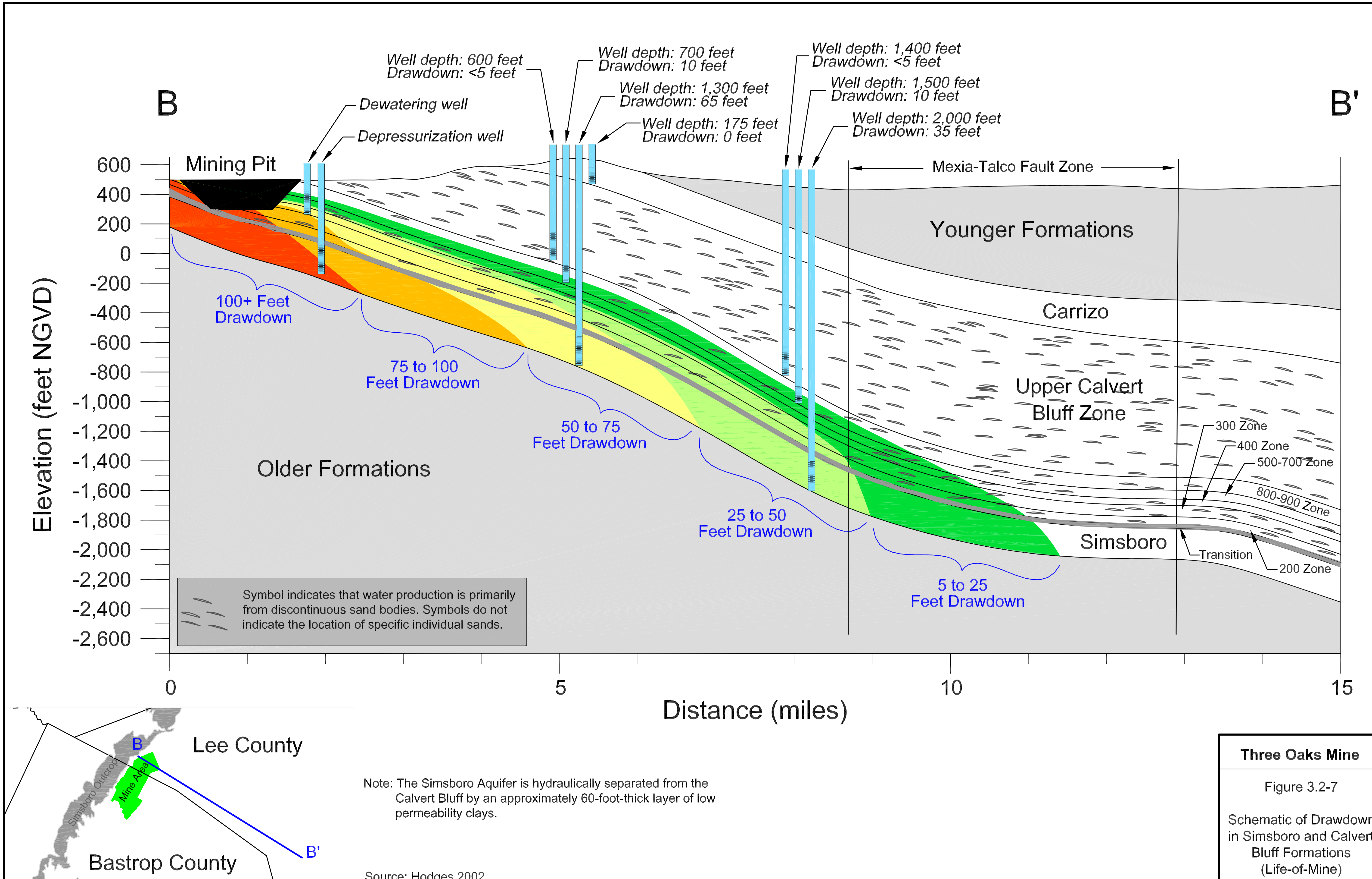
Approximate Drawdown (10-, 20-, 50-, 100-, 200-, and 500-foot intervals)
Drainages
Calvert Bluff Outcrop

N

0 1 2 3 4 5 Miles

Source: Drawdown modeled by ENSR 2002.

7/18/02



Note: The Simsboro Aquifer is hydraulically separated from the Calvert Bluff by an approximately 60-foot-thick layer of low permeability clays.

Source: Hodges 2002.

Three Oaks Mine

Figure 3.2-7

Schematic of Drawdown in Simsboro and Calvert Bluff Formations (Life-of-Mine)

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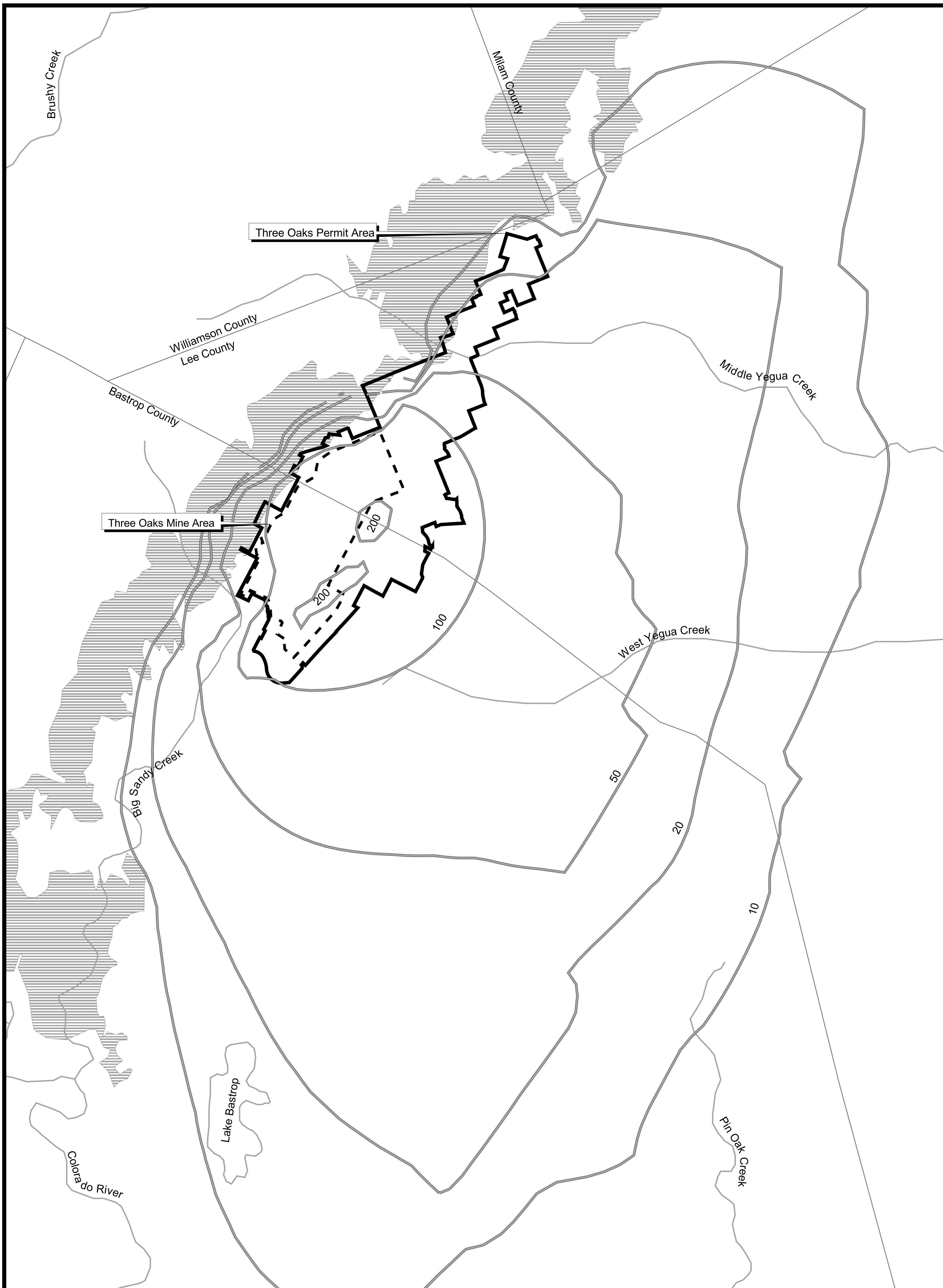


Figure 3.2-8
Estimated Drawdown in the Simsboro Aquifer Year 2030

Three Oaks Mine

Approximate Drawdown (10-, 20-, 50-, 100-, and 200-foot intervals)
Drainages
Simsboro Outcrop

N

0 1 2 3 4 5 Miles

Source: Drawdown modeled by ENSR 2002.

7/18/02

infiltration of precipitation over the undisturbed 95 percent of the Calvert Bluff Formation outcrop and from infiltration of water from the end lakes. Based on studies conducted at the Sandow Mine, resaturation of reclaimed spoil typically is achieved within 20 to 30 years following the completion of reclamation (Pollock 1982), suggesting that water levels in the Calvert Bluff Formation near the reclaimed Sandow Mine pits have reached approximately 90 percent of their pre-mining levels. Away from the mined area and downdip in the artesian portion of the Calvert Bluff, it is anticipated that recovery of groundwater levels may take approximately 100 years due to the slow migration of recharge water through the Calvert Bluff silts and clays.

Simsboro Aquifer Depressurization. Depressurization wells would be installed incrementally over the life of the mine to reduce the head pressure in the artesian Simsboro aquifer to prevent floor heaving in the advancing pit. These wells would be screened in the upper portions of the Simsboro Formation beneath the lowest lignite seam to be mined. Alcoa only would pump a sufficient quantity of groundwater from the Simsboro aquifer (increasing over time to a maximum of 11,000 acre-feet per year) to reduce the artesian head pressure to a level that would permit mining of the lowest targeted lignite zones. If municipal pumpage in the Simsboro aquifer from adjacent counties should contribute to a reduction in the artesian head pressure in the Three Oaks Mine area, then Alcoa would pump less groundwater from the Simsboro to maintain the lowered artesian head pressure. As a result, Alcoa may not need to pump up to the estimated maximum of approximately 11,000 acre-feet per year of groundwater from the Simsboro aquifer to maintain the required artesian head pressure. Modeling of groundwater drawdown in the Simsboro aquifer assumed that Alcoa would pump up to a maximum of approximately 10,000 acre-feet per year from the Simsboro aquifer. An increase of approximately 1,000 acre-feet per year in the maximum pumpage (up to the projected approximately 11,000 acre-feet per year) would have a minimal change in effect to wells and no change in effect to resources associated with the Simsboro outcrop.

Based on data from existing monitoring wells in the proposed Three Oaks Mine area, the current (year 2000) potentiometric surface in the Simsboro aquifer ranges from 400 to 540 feet NGVD. In the outcrop area to the west of the proposed mine, the water levels range from 460 to 540 feet NGVD (**Figure C-6** in Appendix C). Depressurization pumpage would begin at a rate of approximately 3,428 acre-feet per year (2,125 gpm), with the pumpage volume increasing to approximately 10,889 acre-feet per year (6,750 gpm) as the mine advances downdip (Alcoa 2001c [Volume 4]). As previously discussed under Numerical Groundwater Flow Modeling, groundwater modeling has been used to estimate the projected drawdown in the Simsboro aquifer as a result of depressurization at the Three Oaks Mine. **Table 3.2-3** and **Figure 3.2-8** summarize the results of this modeling. The cross-section in **Figure 3.2-7** illustrates the relationship between drawdown in the Simsboro aquifer and the potential drawdown in private wells screened within the Simsboro aquifer at various distances from the proposed Three Oaks Mine.

For year 2030, which would be the approximate end of mining, drawdown in the Simsboro aquifer in the permit area is projected to be approximately 100 to 200 feet. Drawdown in the outcrop of the Simsboro to the west of the mine would be approximately 10 to 50 feet, and the 10-foot drawdown cone would extend approximately 10 to 16 miles beyond the permit boundary and approach the Colorado River near Bastrop, Texas. As mining and depressurization would cease at approximately this time, this would be the maximum extent of the mine-related drawdown in the Simsboro aquifer. With no further mine-related pumpage in the

Simsboro aquifer following the completion of mining (approximately year 2030) and assuming no additional pumpage for other purposes, the potentiometric surface of the aquifer should recover to 90 percent of pre-mining levels within approximately 40 years and 100 percent of pre-mining levels within approximately 100 years (Alcoa 2000 [Volume 10]).

Pumping of depressurization wells would result in a direct impact to water quantity for private and municipal wells that are screened in the Simsboro aquifer and are located within the anticipated drawdown area. The degree of impact would vary depending on the location of a well in relation to the drawdown area. Wells within the area of 20 feet of drawdown may experience sufficient drawdown to require modification of the pump, or depth of pump placement, in order to continue to provide a sufficient supply of water for domestic or municipal use. Wells within the 50-foot or greater drawdown area would be expected to require modification or replacement. Alcoa's proposed groundwater monitoring plan is described in **Table 2-15**. Additional mitigation may be appropriate to provide baseline and operational monitoring data for evaluation of potential mine-related impacts to existing wells within the modeled LOM 20-foot drawdown area of the Simsboro aquifer (see **Figure 3.2-8**) (see mitigation measures GW-1 and GW-2 in Section 3.2.4, Monitoring and Mitigation Measures). If mine-related impacts to private or municipal wells are identified, Alcoa would mitigate the impact as required by the RRC.

The Simsboro aquifer typically is hydraulically separated from any lower Calvert Bluff channel sands by an approximately 60-foot-thick clay zone as well as numerous other clay zones in the Calvert Bluff of very low permeability. These clay zones effectively isolate the Simsboro aquifer from the channel sands in the Calvert Bluff, as shown by multi-well aquifer tests (Alcoa 2000 [Volume 4]). The Carrizo aquifer, which overlies the Calvert Bluff aquifer, is separated from the Simsboro by the same 60-foot-thick clay zone as well as 200 to over 400 feet of low permeability clay in the Calvert Bluff Formation. As a result, groundwater drawdown associated with depressurization of the Simsboro aquifer is not projected to affect groundwater levels in the Calvert Bluff or Carrizo aquifers.

Due to the hydraulic separation of the Simsboro aquifer from the Calvert Bluff aquifer and the determination that the Simsboro physically would not be disturbed under the Proposed Action, groundwater recovery in the outcrop area following the completion of mining partly would be dependent on recharge in the outcrop zone of the formation from infiltration of precipitation. RWHA (Alcoa 2000 [Volume 10]) used the numerical groundwater flow model developed for the Three Oaks Mine to estimate the time required for the Simsboro aquifer to recover from mining operations. Modeling results project that the Simsboro aquifer would reach approximately 90 percent of its pre-mining groundwater level in approximately 40 years following the completion of mining and the cessation of associated depressurization pumping. It is anticipated that complete recovery of the aquifer would take approximately 100 years.

Groundwater Quality Impacts.

<u>Calvert Bluff Aquifer</u>. There would be no impacts to groundwater quality in the Calvert Bluff aquifer as a result of dewatering activities. The removal of storm water runoff and any groundwater seepage from the pits to facilitate mining would minimize the potential for degraded pit water (resulting from oxidation of pyrite) to re-enter the aquifer during the life of the mine.

Water quality in reclaimed mine spoil has been studied at the Sandow Mine by Pollock (1982). Pollock's study showed that groundwater within a mine area reclaimed 25 years prior to his study was similar in water quality to that found in nearby unmined areas. The primary difference was the higher TDS and sulfate levels in the water in reclaimed spoil materials. Pollock concluded that reclaimed spoil has an overall higher permeability to rainwater infiltration than undisturbed Calvert Bluff lithologic units. His study found that in the unsaturated zone above the groundwater in the reclaimed spoil, gypsum and calcite had precipitated. In the saturated zone, approximately 20 to 25 feet below the reclaimed ground surface, the water was anoxic (low in dissolved oxygen), reducing, and sulfate was converting to hydrogen sulfide gas. This left the water elevated in TDS but lowered in sulfate, although the sulfate level was still elevated above observed levels in the non-mined areas of the Calvert Bluff.

Groundwater within the reclaimed spoil at the Sandow Mine was found to have TDS levels of 3,000 to 4,000 mg/l. In comparison, groundwater from the Calvert Bluff aquifer near the reclaimed pit area had background TDS levels of 300 to 1,600 mg/l. Sulfate in the reclaimed spoil groundwater was approximately twice that found in the Calvert Bluff aquifer. Other cations and anions generally were higher in the reclaimed spoil groundwater; however, they were within the range of values found in the Calvert Bluff aquifer. The high carbonate content of the mine spoil served to neutralize any acidity generated by oxidation of pyrite in the unsaturated part of the reclaimed spoils. As a result, the reclaimed spoil groundwater was generally neutral, with a pH range of 6.0 to 7.5 standard units. Downward movement of water into the reclaimed spoil due to infiltration of heavy rains, and eventual outward movement of groundwater into the undisturbed Calvert Bluff Formation, resulted in cation exchange with clays that served to demineralize the water.

Water quality samples were collected from ponds in spoil at the Sandow Mine in 1997 and 1998 (Hodges 2002b). Sampling results indicate that pH in the ponds had a median value of 7.4 standard units, with average TDS of 400 mg/l. The ranges in pH and TDS generally were within those of water quality samples from undisturbed locations within the area. Based on similarities in the lithologic units in the mine areas of the proposed Three Oaks Mine and the existing Sandow Mine, mine spoil groundwater quality at the two sites are anticipated to be similar. As a result of these similarities and based on studies conducted by Pollock (1982), it is anticipated that movement of water through the reclaimed spoil outward into the undisturbed Calvert Bluff Formation would not degrade the water of the Calvert Bluff aquifer. In addition to demineralization resulting from cation exchange with clays in the mine spoil, it is anticipated that the elevated TDS and sulfate levels in water from the reclaimed spoil quickly would be lowered by mixing with the groundwater in the Calvert Bluff aquifer, resulting in water quality within the statistical variation found in the non-mined Calvert Bluff aquifer. As a result, it is anticipated that water quality in the Calvert Bluff aquifer would be approximately the same as pre-mine groundwater quality by the time such waters reach the permit boundary for the Three Oaks Mine.

Alcoa proposes to use bottom ash from the existing Rockdale power generating facility as a road surfacing material in pit and ramp areas of the proposed mine. Bottom ash used on temporary roads would be removed from the roadway during concurrent and final reclamation and placed as backfill in the mine pit, as currently approved at the Sandow Mine. It has been determined that the primary constituents removed from bottom ash by leaching with an acidic solution under the guidelines of USEPA SW-846 for Toxicity Characteristic Leaching Procedure (Test Method 1311) (USEPA 1992) are barium and selenium (Alcoa 2000 [Volume 8]). Based on the results of the leaching tests, the leachate from bottom ash does not meet the regulatory definition of a hazardous waste. As a result, burial of bottom ash in the reclaimed pits should not degrade water in the nearby undisturbed Calvert Bluff aquifer.

Simsboro Aquifer. There would be no impacts to groundwater quality in the Simsboro aquifer as a result of depressurization activities. Due to the hydraulic separation between the Simsboro and Calvert Bluff aquifers as discussed above in Groundwater Quantity Impacts, mining and subsequent backfill of the mine pits would have no impact on groundwater quality in the Simsboro aquifer.

Carrizo Aquifer. As the Carrizo aquifer occurs outside of the permit area (approximately 3 miles to the southeast) and is hydraulically separated from the lower Calvert Bluff and Simsboro aquifers, there would be no impact to groundwater quality in the Carrizo aquifer as a result of the Proposed Action.

No Action Alternative

Under the No Action Alternative, the Three Oaks Mine would not be developed. As a result, impacts to groundwater quantity and quality resulting from the proposed Three Oaks Mine as described above would not occur. Annual and seasonal changes in groundwater level and groundwater quality characteristics would continue as they have in the past, as would changes associated with municipal pumpage.

3.2.3.3 Cumulative Groundwater Impacts

Cumulative Impact Assessment Methodology

Potential cumulative groundwater impacts would be associated with pumpage of groundwater at the existing Sandow and proposed Three Oaks Mines by Alcoa; past, present, and reasonably foreseeable future municipal groundwater pumpage in the Brazos G Regional Water Planning Area (Region G); municipal pumpage of groundwater from counties adjacent to the lower basin area of Region G; and the SAWS contracts with Alcoa and CPS for up to 66,000 acre-feet per year of water from the Sandow and Three Oaks areas (see Section 2.6).

Historical Water Use. Historical water use in Texas has been summarized by the TWDB and is available from their website (www.twdb.state.tx.us). Data for the counties in the lower basin area of Region G and adjacent counties of Region H, Region I, and Region K are presented in **Table 3.2-4**. Water use in Texas, especially in the Region G area, has been related to population growth and water conservation measures. In some counties, water use has declined due to population declines or water conservation. Projections of future water consumption are based on past water use trends in a county, estimated future population growth or decline, and estimated water conservation measures.

Projected Future Water Demand to Year 2050. The TWDB also has estimated future water demand to the year 2050 for each county in Texas; these county estimates are based on regional water plans for each water planning district. The regional water plans are available from the TWDB in their report titled *Water for Texas – 2002* (TWDB 2002a). These data sources were used to develop **Table 3.2-5**.

Table 3.2-4
Historical Water Use in Lower Basin Area of Region G and Adjacent Counties[1]
(acre-feet/year)

County	Year														
	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Anderson	10,765	10,732	11,087	11,613	11,777	11,429	11,114	10,966	10,577	11,812	12,849	12,795	13,512	15,000	14,575
Bastrop	13,352	12,084	11,795	10,670	11,485	13,492	12,528	11,333	11,093	10,816	12,313	12,388	12,992	16,206	12,140
Brazos	29,300	41,104	35,700	34,169	37,538	43,673	38,538	41,264	35,801	37,054	39,815	39,415	44,844	48,408	36,075
Burleson	9,508	11,003	9,696	8,604	9,479	8,128	8,143	9,956	10,833	9,210	8,588	12,173	17,692	13,059	6,029
Fayette	19,208	19,862	20,203	18,031	14,370	21,647	18,415	17,574	18,704	14,516	16,491	19,653	22,016	30,514	16,746
Grimes	3,534	12,876	13,252	10,091	12,800	17,593	13,380	15,969	12,278	9,283	8,982	10,121	10,172	12,966	9,609
Houston	7,064	6,577	6,339	5,724	5,823	5,849	6,043	6,244	6,008	5,952	5,732	6,419	6,165	6,494	6,236
Lee	3,957	4,113	4,169	4,227	4,349	4,496	4,432	4,677	4,557	4,874	5,428	5,491	5,493	5,552	5,258
Leon	3,007	4,411	4,501	4,161	4,641	4,885	4,332	4,459	6,165	6,164	6,299	5,996	6,926	6,641	6,610
Madison	3,256	4,153	4,042	4,041	3,281	3,156	3,605	3,381	3,305	3,510	3,458	3,178	3,444	4,283	3,516
Milam	19,935	32,656	29,703	23,688	33,704	29,345	32,096	32,134	34,470	34,455	45,882	52,313	50,629	55,032	50,608
Robertson	24,856	22,817	23,214	19,929	15,667	22,959	20,036	25,504	28,843	31,671	16,171	25,620	24,748	29,382	21,871
Washington	5,444	6,083	6,013	5,886	5,708	5,982	5,974	6,397	6,192	6,192	6,301	6,337	6,449	7,797	6,553

[1]Includes surface water and groundwater sources.

Source: TWDB 2002c.

The principal water sources available to meet future water demand in the lower basin area of Region G and adjacent counties in Region H, Region I, and Region K are the lower Colorado River alluvium, Brazos River alluvium, Carrizo-Wilcox aquifer, Queen City and Sparta aquifers, Gulf Coast aquifer, and various lakes and reservoirs. **Table 3.2-5** presents both a summary of estimated future regional water use in the lower basin of Region G and adjacent counties, and an estimate of the future regional groundwater demand that may be placed on the Carrizo-Wilcox aquifer system. The estimate of future groundwater demand for the Carrizo-Wilcox aquifer system was developed from the data presented in *Water for Texas – 2002* (TWDB 2002a). As the Carrizo-Wilcox aquifer system is addressed in this EIS, the estimates of future groundwater use from the Carrizo-Wilcox in **Table 3.2-5** were used for developing cumulative impact scenarios to the year 2050 for the lower basin area of Region G.

Cumulative Groundwater Scenarios. Three cumulative groundwater impact scenarios to the year 2050 were considered for the lower basin area of Region G and adjacent counties in Region H, Region I, and Region K. These scenarios include:

1. Regional municipal groundwater demand including the proposed Three Oaks Mine but without the SAWS contract (Three Oaks without SAWS);

2. Regional municipal groundwater demand including the proposed Three Oaks Mine and the Alcoa SAWS contract (Three Oaks with SAWS); and

3. Regional municipal groundwater demand with the SAWS contract but without the Three Oaks Mine (SAWS without Three Oaks; this scenario reflects cumulative impacts associated with the No Action Alternative). This scenario estimates the impacts of regional municipal groundwater demand including the removal of up to 66,000 acre-feet per year of groundwater from the Carrizo-Wilcox for delivery to the City of San Antonio starting in approximately 2013.

A description of the SAWS contract is presented in Section 2.6.2.2, San Antonio Water System Contract.

Cumulative Groundwater Model. The starting point for cumulative impacts was the groundwater model developed by RWHA for the Brazos G Regional Water Planning Area (RWHA 2000). This numerical groundwater model was modified to include all of Bastrop County by expanding the model in the area of that county; this expanded model is referred to as the Modified Region G Model.

The USACE evaluated the Brazos G Regional Water Planning Area (Region G) groundwater model for its applicability in assessing potential environmental impacts in the lower basin area of the Brazos G Regional Water Planning Area and particularly within and near the proposed Three Oaks Mine project area. ENSR and HydroGeo, Inc., the USACE's third-party environmental contractors, evaluated the Region G Model for the USACE.

ENSR and HydroGeo examined the model input files, grid design, boundary conditions, and input parameters to ensure they were suitable for modeling environmental impacts within and adjacent to the proposed Three Oaks Mine project area as well as within Lee, Bastrop, and Milam Counties. In addition, the model was run to examine the model calibration, stability and convergence, and the model's ability to

Table 3.2-5
Estimated Groundwater Demand for Lower Basin Area of Region G and Adjacent Counties
(acre-feet per year)

	Year						
County	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**Aquifer**
Region G							
Brazos County							
Municipal demand	43,694	49,366	54,961	58,822	63,346	67,355	Carrizo-Wilcox (Simsboro)
Manufacturing demand	194	221	244	262	295	329	Brazos River alluvium
Steam electric demand	3,350	3,350	3,350	3,350	3,350	3,350	Brazos River alluvium/Bryan
Mining demand	27	27	28	30	32	34	Sparta
Irrigation demand	0	0	0	0	0	0	Brazos River alluvium
Livestock demand	985	985	985	985	985	985	Gulf Coast/Queen City/Sparta
Estimated total groundwater demand	48,250	53,949	59,568	63,449	68,008	72,053	
Estimated groundwater demand Carrizo-Wilcox	43,599	48,772	53,848	57,535	62,326	66,644	
Burleson County							
Municipal demand	2,196	2,244	2,295	2,357	2,397	2,518	Carrizo-Wilcox
Manufacturing demand	131	145	158	171	182	194	Carrizo-Wilcox
Steam Electric demand	0	0	0	0	0	0	
Mining demand	29	24	18	15	13	13	Queen City/Sparta
Irrigation demand	1,032	757	492	239	14	0	Brazos River alluvium
Livestock demand	1,318	1,318	1,318	1,318	1,318	1,318	Carrizo-Wilcox/Queen City
Estimated total groundwater demand	4,706	4,488	4,281	4,100	3,924	4,043	
Estimated groundwater demand Carrizo-Wilcox	6,409	6,471	6,535	6,610	6,661	6,794	
Grimes County							
Municipal demand	2,778	2,923	3,067	3,237	3,128	3,441	Gulf Coast aquifer
Manufacturing demand	280	314	351	391	435	483	Gulf Coast aquifer
Steam electric demand	0	0	0	0	0	0	Brazos River/Livingston Lake
Mining demand	273	255	236	219	213	212	Gulf Coast aquifer
Irrigation demand	0	0	0	0	0	0	Gulf Coast aquifer
Livestock demand	1,933	1,933	1,933	1,933	1,933	1,933	Gulf Coast aquifer
Estimated total groundwater demand	5,264	5,425	5,587	5,780	5,709	6,069	
Estimated groundwater demand Carrizo-Wilcox	122	122	122	122	122	122	
Lee County							
Municipal demand	3,226	3,383	3,521	3,687	3,877	4,150	Carrizo-Wilcox
Manufacturing demand	6	7	8	9	11	12	Queen City
Steam electric demand	0	0	0	0	0	0	
Mining demand	0	5,000	5,000	5,000	0	0	Carrizo-Wilcox
Irrigation demand	275	268	261	254	247	240	Carrizo-Wilcox
Livestock demand	1,711	1,711	1,711	1,711	1,711	1,711	Carrizo-Wilcox
Alcoa SAWS contract	0	0	0	0	7,500	7,500	Carrizo-Wilcox
Estimated total groundwater demand	5,218	10,369	10,369	10,369	13,346	13,613	

Table 3.2-5 (Continued)

	Year						
County	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**Aquifer**
Estimated groundwater demand Carrizo-Wilcox	5,103	10,179	10,240	10,315	12,909	13,059	
Milam County							
Municipal demand	4,914	4,998	5,021	5,127	5,218	5,346	Carrizo-Wilcox
Manufacturing demand	1,608	1,608	6,608	6,608	6,608	6,608	Brazos River/Carrizo-Wilcox
Steam electric demand	0	5,000	5,000	5,000	0	0	
Mining demand	45,000	0	0	0	0	0	Carrizo-Wilcox
Irrigation demand	0	0	0	0	0	0	Carrizo-Wilcox
Livestock demand	1,627	1,627	1,627	1,627	1,627	1,627	Carrizo-Wilcox
Alcoa SAWS contract	0	40,000	40,000	40,000	40,000	40,000	
Estimated total groundwater demand	53,149	53,233	58,256	58,362	53,453	53,581	
Estimated groundwater demand Carrizo-Wilcox	50,915	53,126	59,611	59,713	59,802	61,456	
Robertson County							
Municipal demand	2,936	3,032	3,104	3,246	3,402	3,598	Carrizo-Wilcox
Manufacturing demand	42	51	61	72	84	98	Carrizo-Wilcox
Steam electric demand	0	0	0	0	0	0	
Mining demand	45	45	45	45	45	45	Brazos River alluvium
Irrigation demand	5,449	4,952	4,757	4,183	3,625	3,083	Carrizo-Wilcox
Livestock demand	1,704	1,704	1,704	1,704	1,704	1,704	Carrizo-Wilcox
Estimated total groundwater demand	10,176	9,784	9,671	9,250	8,860	8,528	
Estimated groundwater demand Carrizo-Wilcox	10,131	9,739	9,626	9,205	8,815	8,483	
Washington County							
Municipal demand	4,459	4,600	4,678	4,682	4,455	4,152	Gulf Coast aquifer and Brazos River alluvium
Manufacturing demand	495	519	538	569	616	663	
Steam electric demand	0	0	0	0	0	0	
Mining demand	131	125	121	119	120	124	
Irrigation demand	205	205	205	205	205	205	
Livestock demand	782	782	782	782	782	782	
Estimated total groundwater demand	6,072	6,231	6,324	6,357	6,178	5,926	
Estimated groundwater demand Carrizo-Wilcox	0	0	0	0	0	0	
Region K							
Bastrop County							
Municipal demand	8,804	10,208	11,681	13,323	14,257	15,479	Carrizo-Wilcox
Manufacturing demand	33	40	48	57	67	78	Carrizo-Wilcox
Steam electric demand	0	0	0	0	0	0	
Mining demand	56	5,046	5,038	5,033	34	43	Carrizo-Wilcox
Irrigation demand	0	0	0	0	0	0	
Alcoa SAWS contract	0	0	0	0	7,500	7,500	Carrizo-Wilcox
Livestock demand	670	670	670	670	670	670	Carrizo-Wilcox approximately 50%
Estimated total groundwater demand	9,563	15,964	17,437	19,083	22,528	23,770	

Table 3.2-5 (Continued)

County	Year						Aquifer
	2000	2010	2020	2030	2040	2050	
Estimated groundwater demand Carrizo-Wilcox	7,091	15,629	17,102	18,748	22,193	23,435	
Fayette County							
Municipal demand	2,361	2,489	2,709	2,958	3,237	3,623	
Manufacturing demand	0	0	0	0	0	0	
Steam electric demand	0	0	0	0	0	0	Surface water
Mining demand	8	6	12	5	4	3	Groundwater
Irrigation demand	0	0	0	0	0	0	Surface water
Livestock demand	1,942	1,942	1,942	1,942	1,942	1,942	Approximately 50% groundwater
Estimated total groundwater demand	3,511	3,637	3,863	4,105	4,383	4,768	
Estimated groundwater demand Carrizo-Wilcox	Carrizo-Wilcox not used in Fayette County						
Region H							
Leon County							
Municipal demand	1,337	1,434	1,540	1,655	1,778	1,919	Carrizo-Wilcox/Queen City
Manufacturing demand	178	191	192	193	194	195	Carrizo-Wilcox
S.E. Power cooling	0	0	0	0	0	0	
Mining demand	1,459	1,045	508	384	327	335	Carrizo-Wilcox
Irrigation demand	0	0	0	0	0	0	
Livestock demand	2,105	2,105	2,105	2,105	2,105	2,105	Carrizo-Wilcox
Estimated total groundwater demand	5,079	4,775	4,345	4,337	4,404	4,554	
Estimated groundwater demand Carrizo-Wilcox	5,437	5,036	4,500	4,377	4,321	4,330	
Madison County							
Municipal demand	2,773	2,720	2,629	2,541	2,393	2,262	Carrizo-Wilcox/Queen City
Manufacturing demand	78	82	85	87	94	99	Carrizo-Wilcox
S.E. Power cooling	0	0	0	0	0	0	
Mining demand	42	36	33	28	27	28	Carrizo-Wilcox
Irrigation demand	50	50	50	50	50	50	Livingston Lake
Livestock demand	1,379	1,379	1,379	1,379	1,379	1,379	Carrizo-Wilcox
Estimated total groundwater demand	4,322	4,267	4,176	4,085	3,943	3,818	
Estimated groundwater demand Carrizo-Wilcox	1,733	1,687	1,648	1,609	1,551	1,500	
Note: Other counties in Region H get groundwater from the Gulf Coast aquifer or Brazos River alluvium.							
Region I							
Houston County							
Municipal demand	3,894	4,469	4,878	6,138	5,746	6,127	Carrizo-Wilcox/Houston Lake
Manufacturing demand	206	244	268	290	327	364	Carrizo-Wilcox/Houston Lake
Mining demand	189	221	259	304	356	417	Sparta
Irrigation demand	591	653	721	847	880	972	Carrizo-Wilcox/Houston Lake
Livestock demand	1,902	2,061	2,233	2,420	1,849	1,992	Carrizo-Wilcox/Queen City
Estimated total	6,782	7,648	8,359	9,999	9,158	9,872	

Table 3.2-5 (Continued)

	Year						
County	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**Aquifer**
groundwater demand							
Estimated groundwater demand Carrizo-Wilcox	833	833	833	833	833	833	
Anderson County							
Municipal demand	9,883	10,469	10,957	11,486	11,904	12,537	Carrizo-Wilcox/Queen City
Manufacturing demand	153	164	172	179	194	208	Carrizo-Wilcox/Palestine Lake
Steam electric	11,209	11,209	11,209	11,209	11,209	11,209	Lake Palestine surface water
Mining demand	252	168	93	61	40	31	Carrizo-Wilcox
Irrigation demand	484	484	484	484	484	484	Carrizo-Wilcox/Queen City
Livestock demand	2,138	2,138	2,138	2,138	2,138	2,138	Carrizo-Wilcox/Queen City
Estimated total groundwater demand	24,119	24,632	25,053	25,557	25,969	26,607	
Estimated groundwater demand Carrizo-Wilcox	8,114	8,041	7,974	7,949	7,943	7,948	

Note: Region I groundwater from Carrizo-Wilcox is calculated based on other water sources listed and assumption that remaining groundwater comes from Carrizo-Wilcox.
Mining demand for Lee, Bastrop, and Milam Counties based on data from Alcoa for the existing Sandow Mine and proposed Three Oaks Mine.
Three Oaks Mine and SAWS-related pumpage divided equally between Lee and Bastrop Counties.

Source: Alcoa 2000 (Volume 4); TWDB 2002b.

replicate the results presented in RWHA's, report entitled: *Brazos G Regional Water Planning Area Carrizo-Wilcox Ground Water Flow Model and Simulation Results* (RWHA 2000). A model input parameter sensitivity evaluation was conducted for horizontal hydraulic conductivity, storage coefficients, vertical leakance for each layer, evapotranspiration, and recharge. These input parameters were varied in the model to determine the sensitivity of the model calibration to the input parameter and to determine the sensitivity of predicted model impacts to the input parameter. For the Region G Model, the model was found to be very sensitive to horizontal hydraulic conductivity and moderately sensitive to recharge and vertical leakance. The model was not sensitive to the other input parameters.

The Region G Model subsequently was modified by expanding the area in Bastrop County around and near the Colorado River. This was done at the request of the USACE to more accurately evaluate the effects on the Colorado River. The Modified Region G Model was evaluated in a manner similar to that completed for the Region G Model of RWHA (2000). The results were found to be basically the same. The results of the evaluation of the Modified Region G Model by ENSR and HydroGeo, Inc, are available in a report entitled: *Review of the Modified Region G Regional Water Planning Area Groundwater Flow Model for Groundwater Analyses in the Three Oaks Mine EIS* (ENSR Corporation and HydroGeo, Inc. 2002b). This report is on file with the Fort Worth District of the USACE.

The USGS evaluated the Modified Region G Model from the standpoint of its representation of the physical site conditions within and around the proposed Three Oaks Mine area as well as throughout the lower basin area of the Brazos G Regional Water Planning Area. The USGS commented on specific aspects of the model design, particularly the design of the river cells, the use of evapotranspiration in the model, the method used to determine starting heads, the boundary conditions used in the model, and the model's overall ability to determine groundwater availability in the future as well as to evaluate groundwater drawdown impacts due to regional municipal groundwater pumpage. The USACE has provided additional information in response to the USGS comments. The peer review comment letter from Mr. Rene Barker of the USGS is on file with the Fort Worth District of the USACE .

The future allocation of groundwater demand among the three principal aquifers of the Carrizo-Wilcox aquifer system (Simsboro, Calvert Bluff, and Carrizo) was based on the groundwater wells in the model for the year 2000. Data from **Table 3.2-5** then were used in the Modified Region G Model for years 2000, 2030, and 2050 to estimate cumulative impacts in the project area. Year 2030 was selected as it approximately represents the projected end of mining at the proposed Three Oaks Mine. Year 2050 was chosen as it approximately represents 50 years into the future with SAWS and regional pumpage and is the most distant projection of water demand available from the TWDB.

Under the Three Oaks without SAWS and the Three Oaks with SAWS scenarios, modeling of groundwater drawdown in the Simsboro aquifer assumed that Alcoa would pump approximately 10,000 acre-feet per year during the LOM for depressurization purposes. As discussed under Simsboro Aquifer Depressurization in Section 3.2.3.2, the goal of Alcoa's depressurization program would be to pump a sufficient quantity of groundwater from the Simsboro aquifer to prevent floor heaving in the pit, thereby facilitating mining. As a result, if municipal and SAWS pumpage in the Simsboro aquifer reduces the artesian head pressure in the mine area, then Alcoa's depressurization goals under these two scenarios would be met through a corresponding reduction in mine-related pumpage from the Simsboro aquifer.

Projected cumulative impacts to the Calvert Bluff and Simsboro aquifers are described below. Potential regional impacts to the Carrizo aquifer associated with regional municipal pumpage are presented in Appendix D. The proposed Three Oaks Mine is not projected to affect the Carrizo aquifer; therefore, a detailed discussion of the Carrizo aquifer is not presented in this EIS.

Existing regional groundwater levels and estimated regional groundwater drawdown projections for the lower basin area of the Modified Region G Model domain also are presented in Appendix D. These regional projections are the results of modeling the potential cumulative groundwater drawdown for the Three Oaks Mine. These projections are not discussed in the EIS text, because most of the lower basin area of Region G is outside of the area that potentially would be affected by groundwater pumping at the Three Oaks Mine, principally Milam, Lee, and Bastrop Counties. Therefore, these areas are not within the Three Oaks Mine cumulative effects area. Starting water levels for the year 2000 and the estimated regional groundwater drawdown for years 2000 to 2030 and years 2000 to 2050 are presented in Appendix D. These figures were generated using the Modified Region G Model with the same cumulative impact scenarios that are presented in this section (i.e., Three Oaks without SAWS, Three Oaks with SAWS, and SAWS without Three Oaks).

<u>**Three Oaks without SAWS**</u>

This cumulative impact scenario includes regional municipal pumpage and the proposed Three Oaks Mine pumpage. The Three Oaks Mine would initiate pumpage in approximately year 2003 and end pumpage in approximately year 2030. The Sandow Mine will cease mine-related pumpage in approximately year 2003; however, 5,000 acre-feet per year of pumpage will continue through year 2030 for the power plant. All pumpage at Sandow will cease after year 2030. Regional municipal pumpage is shown in **Table 3.2-5**. **Table 3.2-6** summarizes the results of modeling this cumulative impact scenario.

Cumulative Drawdown in the Calvert Bluff Aquifer. Drawdown in the Calvert Bluff aquifer at year 2030 (**Figure 3.2-9**) is projected to be approximately 10 to 20 feet in the vicinity of the Three Oaks Mine. Drawdown in the outcrop area of the Calvert Bluff is projected to be approximately 10 feet. These drawdown estimates are for the entire Calvert Bluff Formation (upper, 200 lignite zone, and 800 lignite zone) within the area of effect. They differ from the projected drawdown identified under direct impacts (**Table 3.2-3**), as direct impacts are projected to affect only the groundwater levels in the sand lenses that are associated with the 200 and 800 lignite zones in the lower one-third of the Calvert Bluff Formation (see Section 3.2.3.2). Drawdown in the Calvert Bluff near the Colorado River in Bastrop County is projected to be approximately 10 feet or less.

Drawdown in the Calvert Bluff Formation at year 2050 (**Figure 3.2-10**) is projected to be approximately 10 feet or less near the Three Oaks Mine and in the outcrop area of the Calvert Bluff from the Three Oaks Mine area to the Sandow Mine area. Drawdown at the Colorado River also is projected to be approximately 10 feet or less.

Cumulative Drawdown in the Simsboro Aquifer. Drawdown in the Simsboro aquifer for year 2030 (**Figure 3.2-11**) is projected to be approximately 70 to 80 feet in the Three Oaks Mine area and 20 to 50 feet

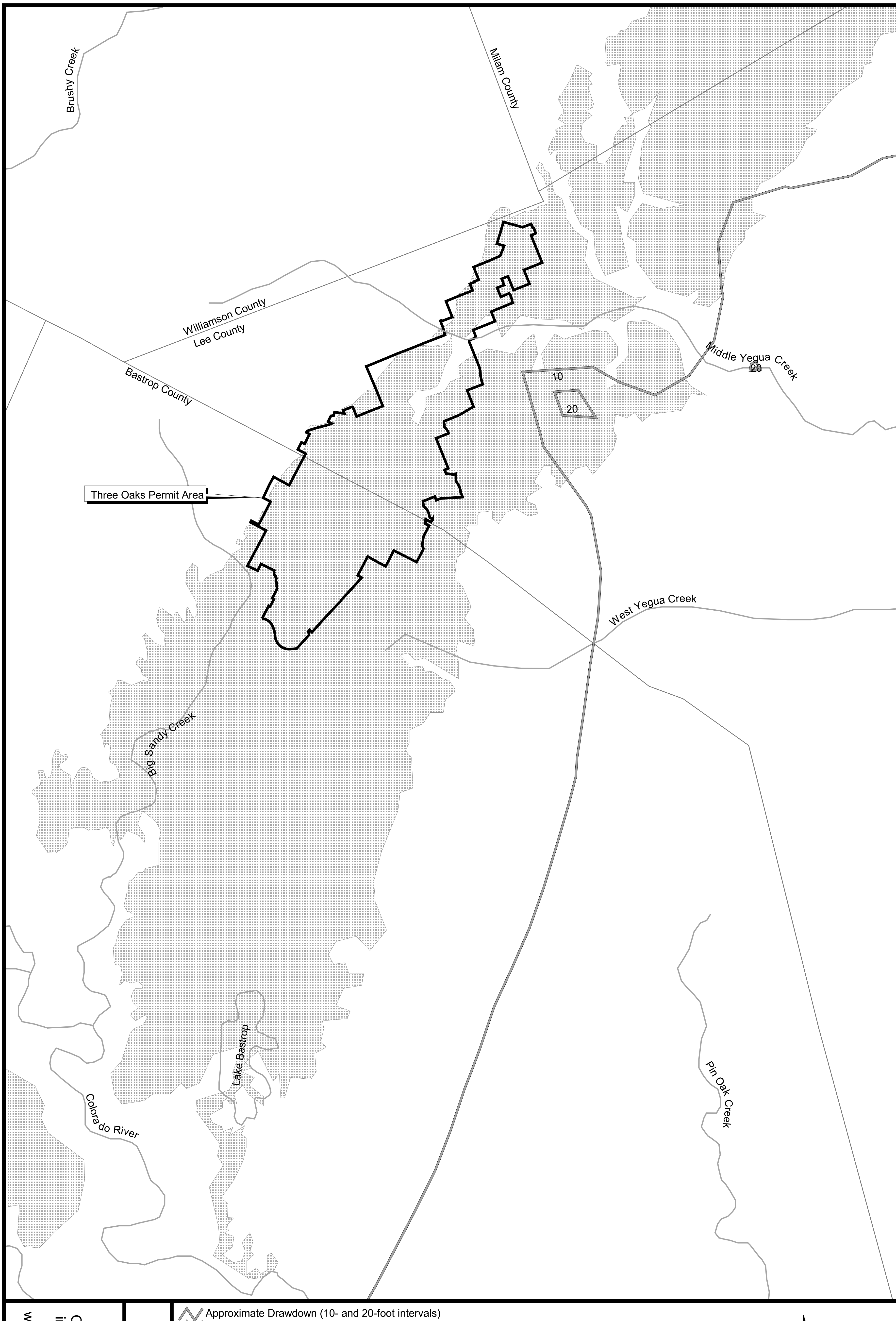
Table 3.2-6
Summary of Estimated Cumulative Groundwater Impacts

Carrizo-Wilcox Aquifer	Calvert Bluff Aquifer	Simsboro Aquifer
Groundwater Levels in Year 2000		
	Groundwater levels range from 440 to 600 feet amsl. Most levels in the Three Oaks Mine area range from 440 to 460 feet amsl.	Regional groundwater levels range from 400 to 540 feet amsl. Levels in the outcrop area range from 460 to 540 feet amsl. Levels in the Three Oaks Mine area range from 400 to 440 feet amsl.
Cumulative Impact Scenarios		
Regional Municipal Groundwater Use Plus Three Oaks Mine (Three Oaks without SAWS)		
Year 2030		
Three Oaks Mine and vicinity (Milam, Lee, and Bastrop Counties)	10 to 20 feet of drawdown in Three Oaks Mine area. Represents average impact for entire Calvert Bluff aquifer.	70 to 80 feet of drawdown in the Three Oaks Mine area.
Outcrop area in Milam, Lee, and Bastrop Counties near Three Oaks Mine	10 feet or less of drawdown in outcrop area. Average for entire Calvert Bluff aquifer.	20 to 50 feet of drawdown in the outcrop area west of Three Oaks Mine.
Colorado River and Bastrop County	10 feet or less of drawdown near Colorado River.	20 to 50 feet of drawdown.
Year 2050		
Three Oaks Mine and vicinity (Milam, Lee, and Bastrop Counties)	10 feet or less of drawdown averaged over entire Calvert Bluff aquifer.	Average of approximately 60 feet of drawdown.
Outcrop area in Milam, Lee, and Bastrop Counties near Three Oaks Mine	10 feet or less of drawdown averaged over entire Calvert Bluff aquifer.	20 to 50 feet of drawdown.
Colorado River and Bastrop County	10 feet or less of drawdown.	20 to 50 feet of drawdown.
Regional Municipal Groundwater Use Plus Three Oaks Mine and SAWS (Three Oaks with SAWS)[1]		
Year 2030		
Three Oaks Mine and vicinity (Milam, Lee, and Bastrop Counties)	20 feet of drawdown near the Three Oaks Mine.	60 to 100 feet of drawdown at Three Oaks Mine. 100 to 140 feet of drawdown at Sandow Mine.
Outcrop area in Milam, Lee, and Bastrop Counties near Three Oaks Mine	10 to 20 feet of drawdown averaged over entire Calvert Bluff aquifer.	30 to 50 feet of drawdown in outcrop west of Three Oaks Mine. 40 to 100 feet of drawdown in outcrop west of Sandow Mine.
Colorado River and Bastrop County	10 feet of drawdown at Colorado River.	10 to 50 feet of drawdown in Bastrop County near Colorado River.

Table 3.2-6 (Continued)

Carrizo-Wilcox Aquifer	Calvert Bluff Aquifer	Simsboro Aquifer
Year 2050		
Three Oaks Mine and vicinity (Milam, Lee, and Bastrop Counties)	10 feet or less of drawdown.	100 to 180 feet of drawdown at Three Oaks Mine. 180 to 230 feet of drawdown at Sandow Mine.
Outcrop area in Milam, Lee, and Bastrop Counties near Three Oaks Mine	10 feet or less of drawdown.	70 to 100 feet of drawdown west of Three Oaks Mine. 100 to 180 feet of drawdown west of Sandow Mine.
Colorado River and Bastrop County	10 feet of drawdown averaged over entire Calvert Bluff aquifer.	10 to 80 feet of drawdown.
Regional Municipal Groundwater Use Plus Saws Pumpage (No Action Alternative – SAWS without Three Oaks)[1]		
Year 2030		
Three Oaks Mine and vicinity (Milam, Lee, and Bastrop Counties)	10 feet of drawdown.	70 to 130 feet of drawdown at Three Oaks Mine. 100 to 140 feet of drawdown at Sandow Mine.
Outcrop area in Milam, Lee, and Bastrop Counties near Three Oaks Mine	10 feet of drawdown.	40 to 70 feet of drawdown west of Three Oaks Mine. 50 to 100 feet of drawdown west of Sandow Mine.
Colorado River and Bastrop County	10 feet of drawdown.	10 to 50 feet of drawdown.
Year 2050		
Three Oaks Mine and vicinity (Milam, Lee, and Bastrop Counties)	10 feet of drawdown.	100 to 210 feet of drawdown at Three Oaks Mine. 200 to 240 feet of drawdown at Sandow Mine.
Outcrop area in Milam, Lee, and Bastrop Counties near Three Oaks Mine	10 feet of drawdown.	70 to 100 feet of drawdown west of Three Oaks Mine. 100 to 200 feet of drawdown west of Sandow Mine.
Colorado River and Bastrop County	10 feet of drawdown.	10 to 80 feet of drawdown.

[1]Under the Three Oaks plus SAWS scenario, pumpage for SAWS from the Three Oaks site during the LOM would vary depending on the volume of depressurization pumpage required (increasing up to a maximum of 11,000 acre-feet per year) (conservatively modeled at 10,000 acre-feet per year during the LOM). Under the SAWS without Three Oaks scenario, SAWS pumpage from the Three Oaks site would be greater (15,000 acre-feet per year) during the same period. As a result, drawdown would be slightly greater under the SAWS without Three Oaks scenario.



Three Oaks Mine

Figure 3.2-9
Cumulative Drawdown
in Calvert Bluff Aquifer
Three Oaks
without SAWS Scenario
Year 2030

Approximate Drawdown (10- and 20-foot intervals)
Drainages
Calvert Bluff Outcrop

Source: Drawdown modeled by ENSR 2002.

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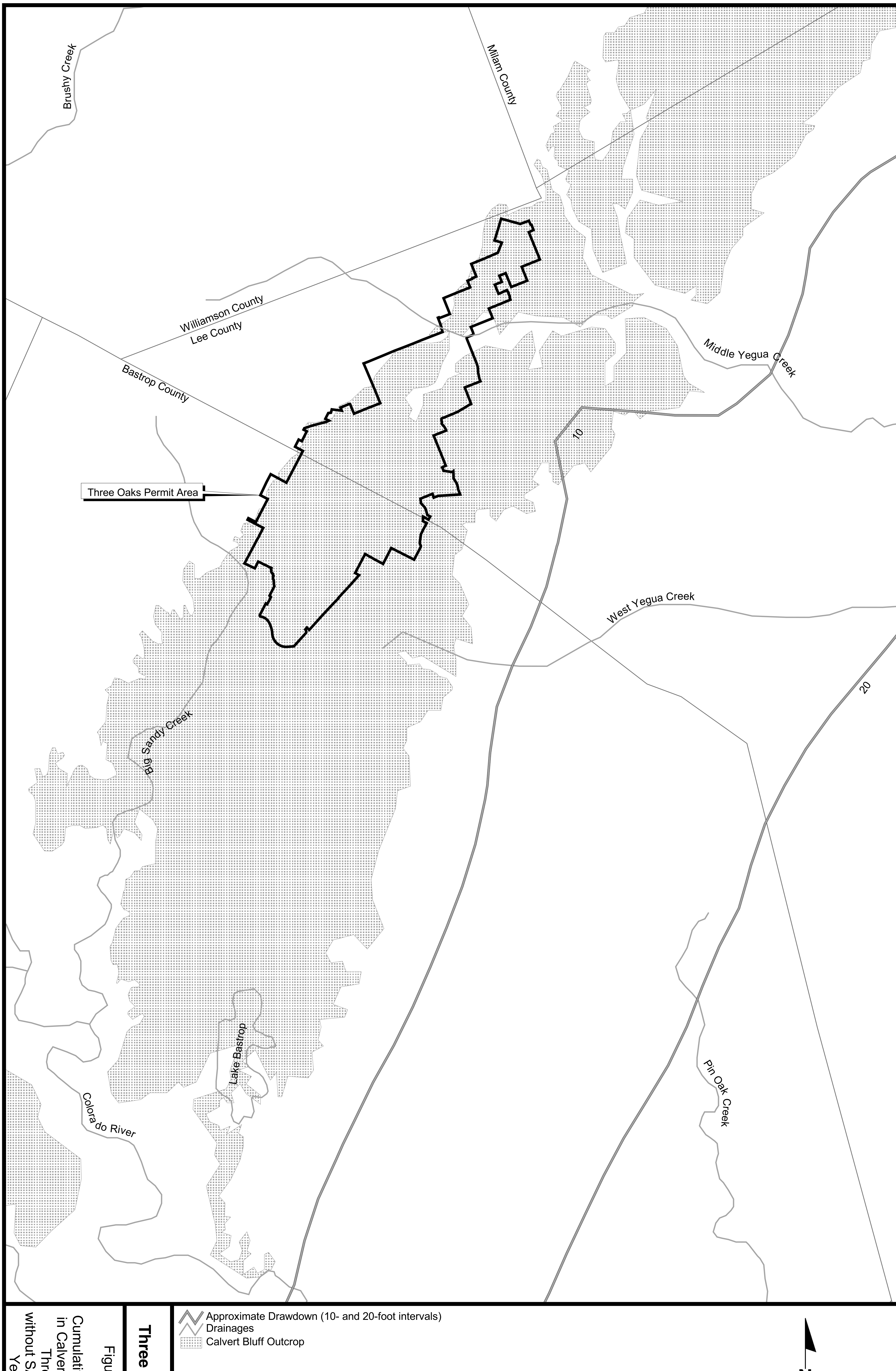


Three Oaks Mine

Figure 3.2-10
Cumulative Drawdown
in Calvert Bluff Aquifer
Three Oaks
without SAWS Scenario
Year 2050

Source: Drawdown modeled by ENSR 2002.

7/18/02

Approximate Drawdown (10-, 20-, and 50-foot intervals)
Approximate 10-Foot Drawdown, Three Oaks Mine Direct Impacts, Year 2030
Drainages
Simsboro Outcrop

N

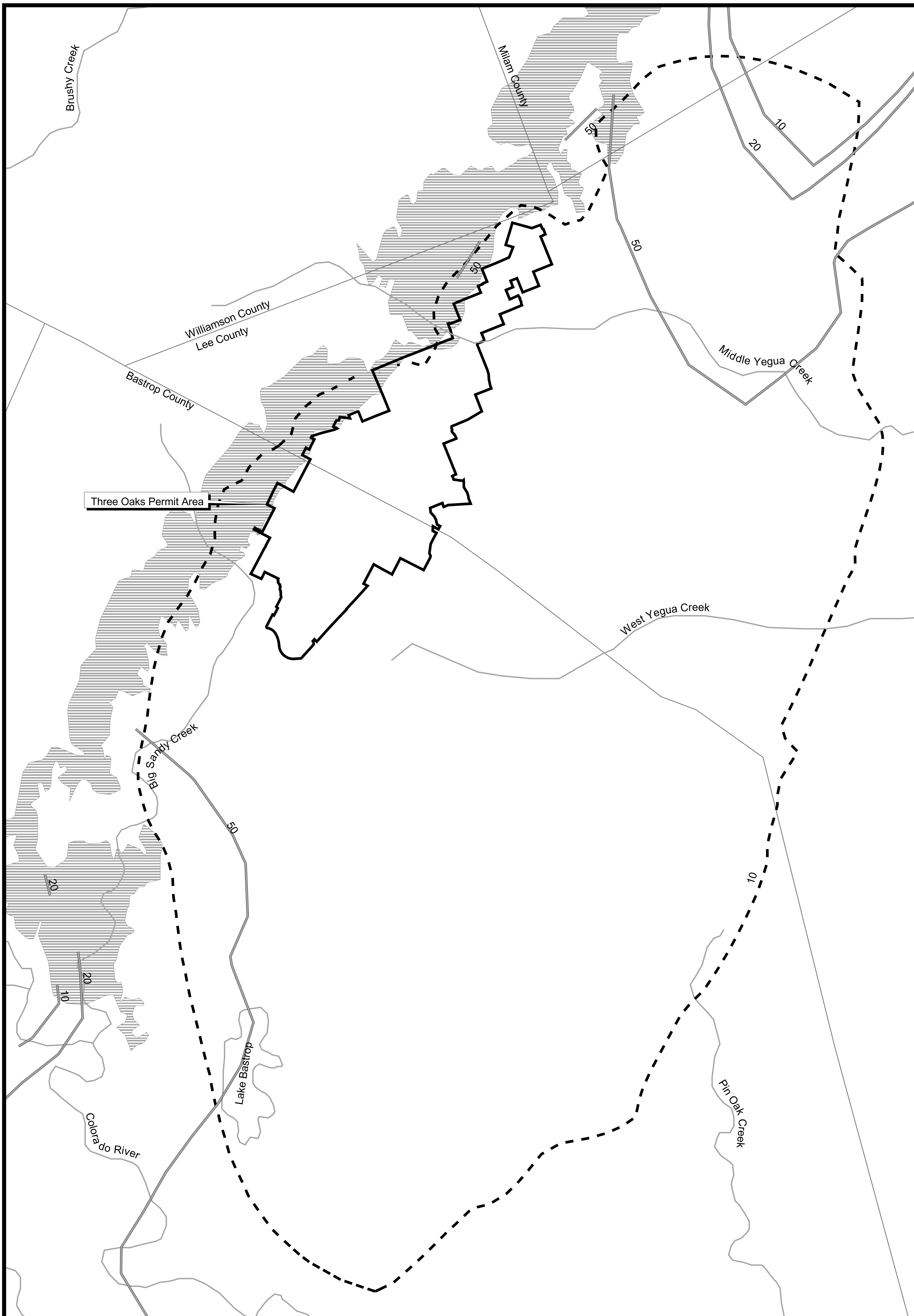
0 1 2 3 4 5 Miles

Source: Drawdown modeled by ENSR 2002.

Three Oaks Mine

Figure 3.2-11
Cumulative Drawdown
in Simsboro Aquifer
Three Oaks
without SAWS Scenario
Year 2030

7/18/02



Approximate Drawdown (10-, 20-, and 50-foot intervals)
Approximate 10-Foot Drawdown, Three Oaks Mine Direct Impacts, Year 2030
Drainages
Simsboro Outcrop

N

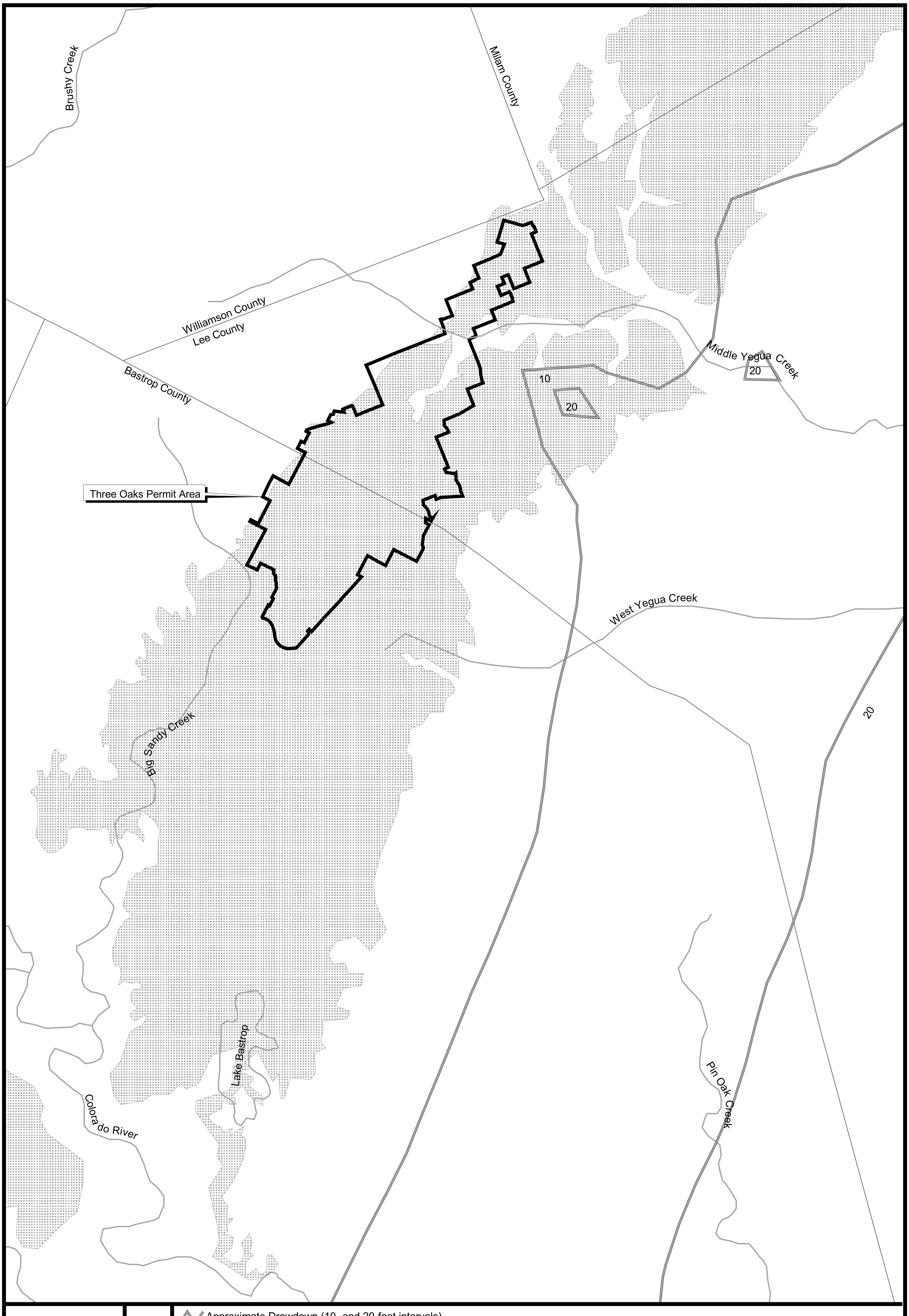
0 1 2 3 4 5 Miles

Source: Drawdown modeled by ENSR 2002.

Three Oaks Mine

Figure 3.2-12
Cumulative Drawdown in Simsboro Aquifer
Three Oaks without SAWS Scenario
Year 2050

7/18/02



Three Oaks Mine

Figure 3.2-13
Cumulative Drawdown
in Calvert Bluff Aquifer
Three Oaks
with SAWS Scenario
Year 2030

7/18/02

in the Simsboro aquifer outcrop west of the Three Oaks Mine. Drawdown at the Colorado River is projected to be approximately 20 to 50 feet. For comparison, the direct impacts to groundwater drawdown in the Simsboro aquifer (100 to 200 feet) in the Three Oaks Mine area (**Table 3.2-3** and **Figure 3.2-8**) are projected to be greater than the cumulative impacts projected by the Modified Region G Model due to the greater detail (small cell size) of the Three Oaks LOM Model that was used for modeling direct impacts in the mine area. The Modified Region G Model used for cumulative impacts has large cells (1 mile x 1 mile), averages drawdown over the entire cell and has less detail such as faulting which affects drawdown. This averaging and absence of site-specific detail results in an overall smaller projected drawdown in the Three Oaks Mine area.

Drawdown in the Simsboro aquifer for year 2050 (**Figure 3.2-12**) is projected to be approximately 60 feet in the Three Oaks Mine area and 20 to 50 feet in the outcrop area west of the Three Oaks Mine. Drawdown at the Colorado River also is projected to be approximately 20 to 50 feet.

<u>Three Oaks with SAWS</u>

The maximum effect of groundwater use from the Carrizo-Wilcox aquifer system is modeled in this cumulative impact scenario. The Three Oaks Mine would initiate pumpage in approximately year 2004 and end in approximately year 2030. A portion of the groundwater from the Three Oaks Mine would go to SAWS starting in approximately year 2013 (up to a maximum of 11,000 acre-feet per year from the Simsboro aquifer). SAWS pumpage from the Simsboro aquifer in the Three Oaks Mine area would increase to 15,000 acre-feet per year in approximately year 2031. The Sandow Mine will cease mining operations in approximately year 2005; however, it will continue pumping 5,000 acre-feet per year for power plant use through year 2030. Pumpage for SAWS would begin in the Sandow Mine area in approximately 2013, and wells in the Simsboro would begin pumping approximately 40,000 acre-feet per year until year 2050. It should be noted that the quantity of water pumped for SAWS would correspondingly reduce the quantity of water pumped for mine depressurization. Regional municipal pumpage was based on the estimated groundwater demand for the Carrizo-Wilcox aquifer system shown in **Table 3.2-5**. **Table 3.2-6** summarizes the results of model projections for the Three Oaks plus SAWS cumulative impact scenario.

Cumulative Drawdown in the Calvert Bluff Aquifer. For year 2030 (**Figure 3.2-13**), drawdown near the Three Oaks Mine is projected to be approximately 20 feet averaged over the entire (upper and lower) Calvert Bluff Formation. Drawdown in the outcrop area of the Calvert Bluff from the Three Oaks Mine area to the Sandow Mine area is projected to average approximately 10 to 20 feet. Drawdown at the Colorado River is projected to be approximately 10 feet.

For year 2050 (**Figure 3.2-14**), drawdown in the Calvert Bluff is projected to be 10 feet or less throughout the extent of the formation from the Sandow Mine area to the Three Oaks Mine area to the Colorado River.

Cumulative Drawdown in the Simsboro Aquifer. For year 2030 (**Figure 3.2-15**), drawdown in the Simsboro aquifer is projected to be approximately 60 to 100 feet in the Three Oaks Mine area and 100 to 140 feet in the Sandow Mine area. Projected drawdown in the Simsboro outcrop area west of the Three Oaks Mine would be approximately 30 to 50 feet, with 40 to 100 feet of drawdown in the Simsboro outcrop area west of the Sandow Mine. Projected drawdown at the Colorado River in Bastrop County would be approximately 10 to 50 feet. (See the discussion under Cumulative Groundwater Scenarios in Section 3.2.3.3 relative to potential reductions in Three Oaks Mine depressurization pumpage based on municipal and SAWS-induced drawdown in the Simsboro aquifer.)

For year 2050 (**Figure 3.2-16**), projected drawdown in the Simsboro aquifer in the Three Oaks Mine area would be approximately 100 to 180 feet, and projected drawdown near the Sandow Mine would be approximately 180 to 230 feet. Projected drawdown in the Simsboro outcrop area west of the Three Oaks Mine would be approximately 70 to 100 feet, and projected drawdown in the outcrop area west of the Sandow Mine would be approximately 100 to 180 feet. Projected drawdown at the Colorado River in Bastrop County would be approximately 10 to 80 feet.

SAWS without Three Oaks (No Action Alternative)

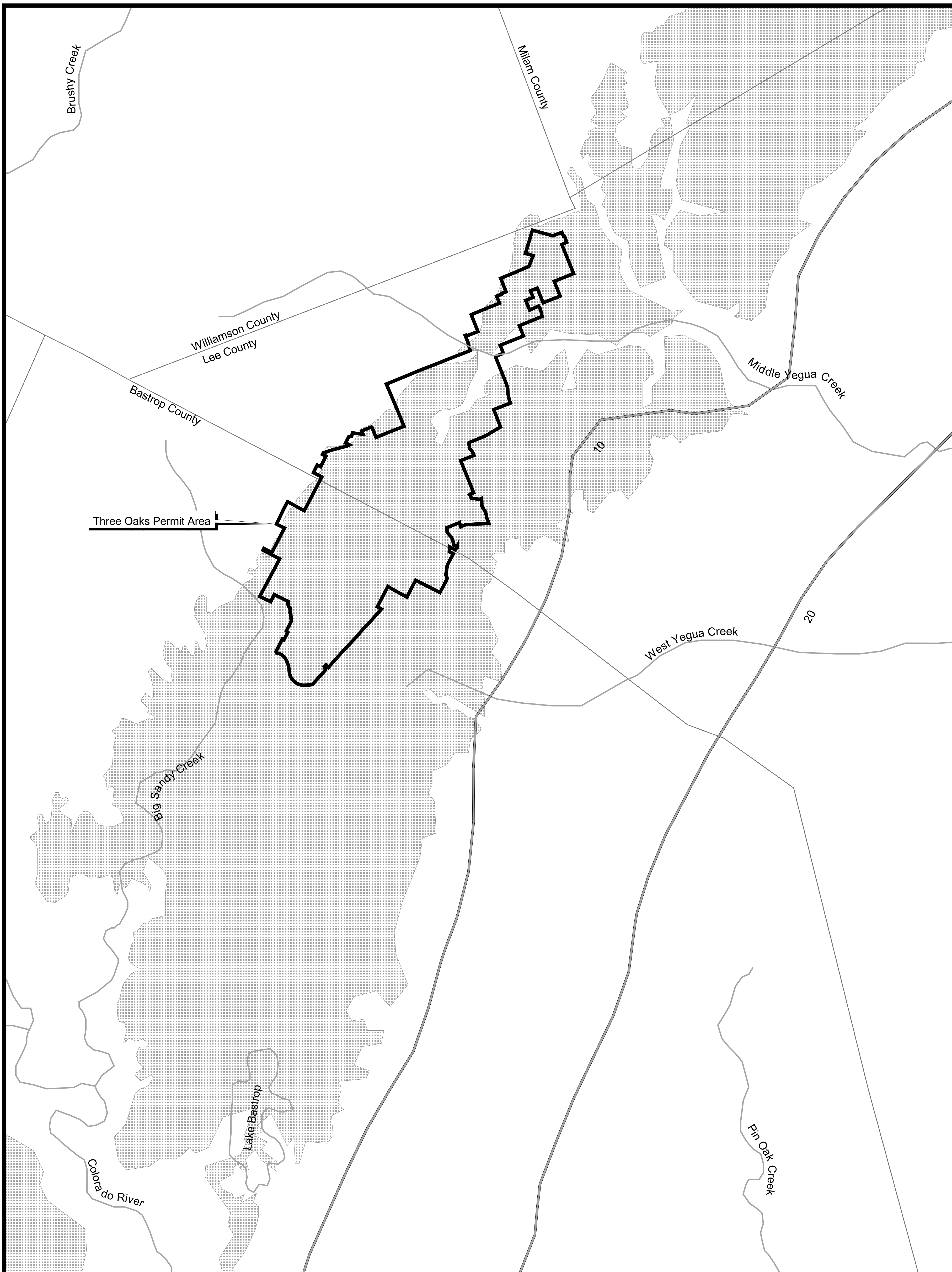
This cumulative impact scenario depicts regional municipal groundwater demand in the Carrizo-Wilcox aquifer system with the addition of the proposed SAWS pumpage in the area of the existing Sandow Mine and in the area of the proposed Three Oaks Mine. Although the Three Oaks Mine would not be developed under this scenario, wells would be installed at the proposed mine site to provide for SAWS pumpage. SAWS pumpage would begin in approximately year 2013 with 40,000 acre-feet per year of pumpage from the Simsboro aquifer in the Sandow Mine area and 15,000 acre-feet per year of pumpage from the Simsboro aquifer in the area of the proposed Three Oaks Mine. This pumpage would continue to approximately year 2050 and potentially beyond. **Table 3.2-6** summarizes the model results of this cumulative impact scenario.

Cumulative Drawdown in the Calvert Bluff Aquifer. For year 2030 (**Figure 3.2-17**), approximately 10 feet of drawdown in the Calvert Bluff aquifer is projected near the Colorado River in Bastrop County due to regional pumpage in the Calvert Bluff in Bastrop County. Approximately 10 feet or less of drawdown is projected to occur in the Calvert Bluff outcrop area near the Three Oaks and Sandow Mine areas.

For year 2050 (**Figure 3.2-18**), drawdown in the Calvert Bluff is projected to be approximately 10 feet at the Colorado River due to regional pumpage.

Cumulative Drawdown in the Simsboro Aquifer. For year 2030 (**Figure 3.2-19**), drawdown in the vicinity of the Three Oaks Mine is projected to be approximately 70 to 130 feet largely due to SAWS pumpage in the Three Oaks Mine area. Drawdown in the Sandow Mine area is projected to be approximately 100 to 140 feet. Drawdown in the outcrop area west of the Three Oaks Mine is projected to be approximately 40 to 70 feet, and drawdown in the outcrop area west of the Sandow Mine is projected to be approximately 50 to 100 feet. Drawdown at the Colorado River in Bastrop County is projected to be approximately 10 to 50 feet.

For year 2050 (**Figure 3.2-20**), drawdown in the vicinity of the Three Oaks Mine is projected to be approximately 100 to 210 feet; in the vicinity of the Sandow Mine, drawdown is projected to be approximately 200 to 240 feet. Drawdown in the outcrop area west of the Three Oaks Mine is projected to be approximately 70 to 100 feet, and drawdown in the outcrop area west of the Sandow Mine is projected to be approximately 100 to 200 feet. Drawdown at the Colorado River is projected to be approximately 10 to 80 feet.



Approximate Drawdown (10- and 20-foot intervals)
Drainages
Calvert Bluff Outcrop

N

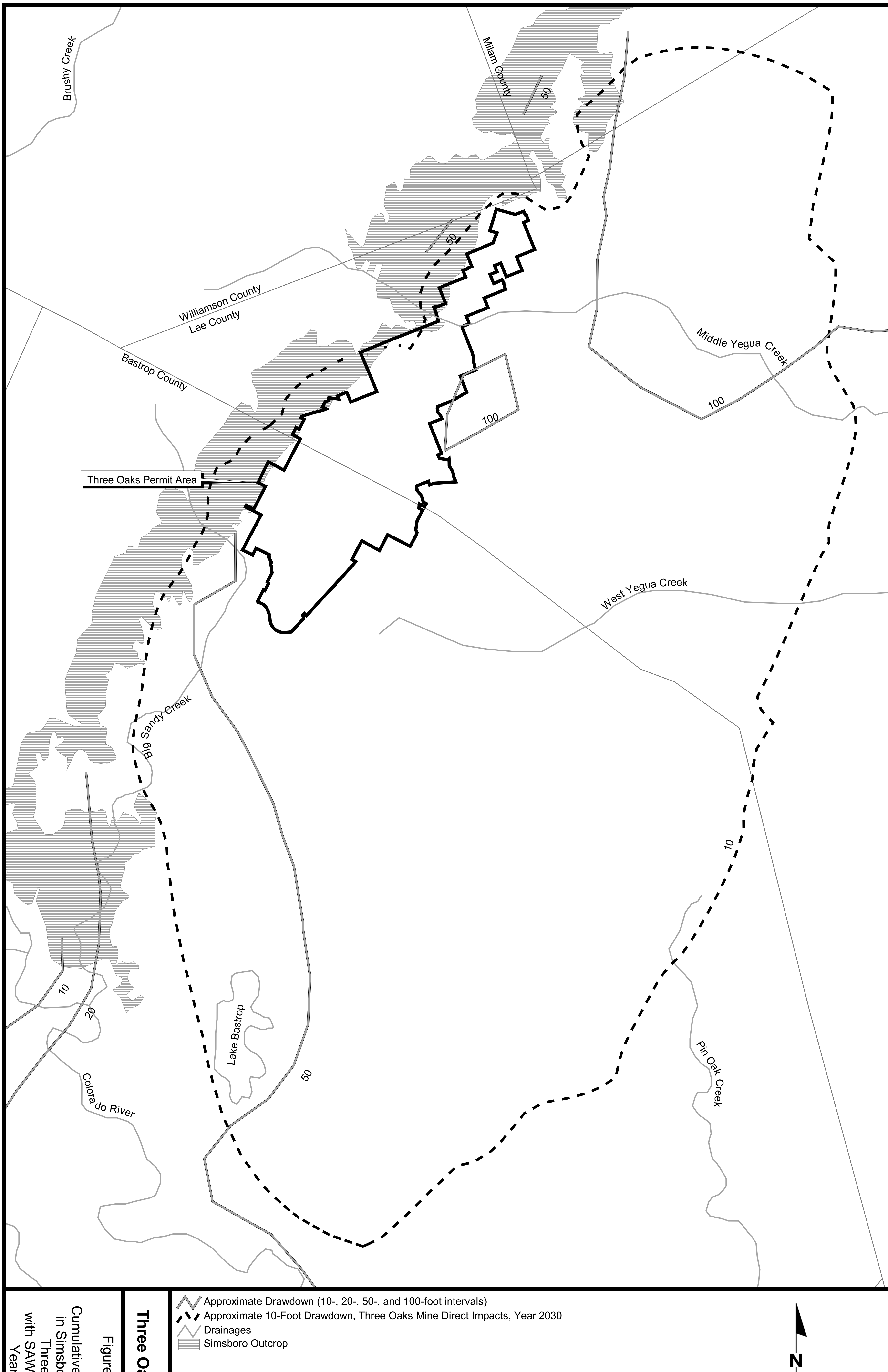
0 1 2 3 4 5 Miles

Source: Drawdown modeled by ENSR 2002.

Three Oaks Mine

Figure 3.2-14
Cumulative Drawdown
in Calvert Bluff Aquifer
Three Oaks
with SAWS Scenario
Year 2050

7/18/02

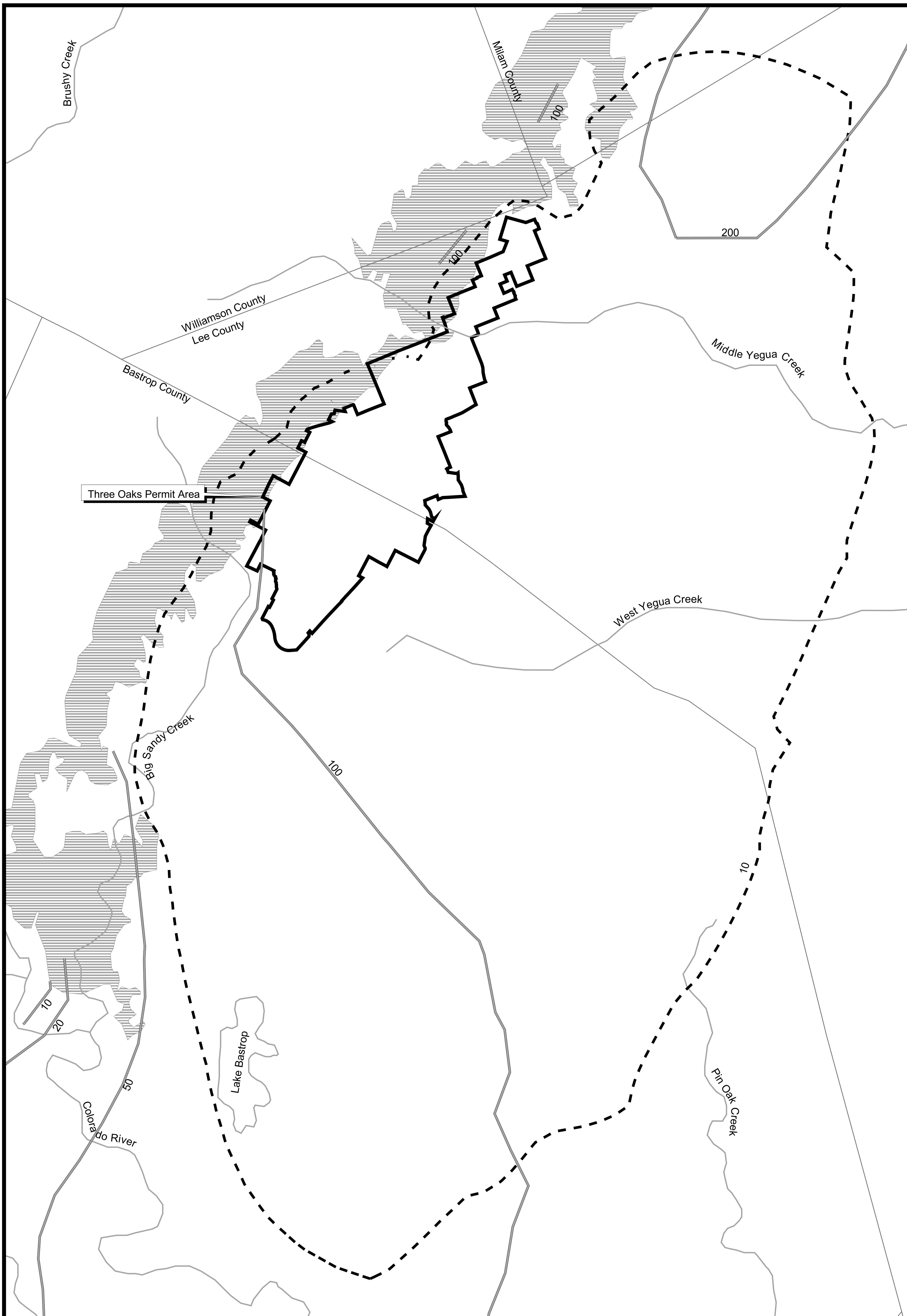


Source: Drawdown modeled by ENSR 2002.

Three Oaks Mine

Figure 3.2-15
Cumulative Drawdown
in Simsboro Aquifer
Three Oaks
with SAWS Scenario
Year 2030

7/18/02



Approximate Drawdown (10-, 20-, 50-, 100-, and 200-foot intervals)
Approximate 10-Foot Drawdown, Three Oaks Mine Direct Impacts, Year 2030
Drainages
Simsboro Outcrop

N

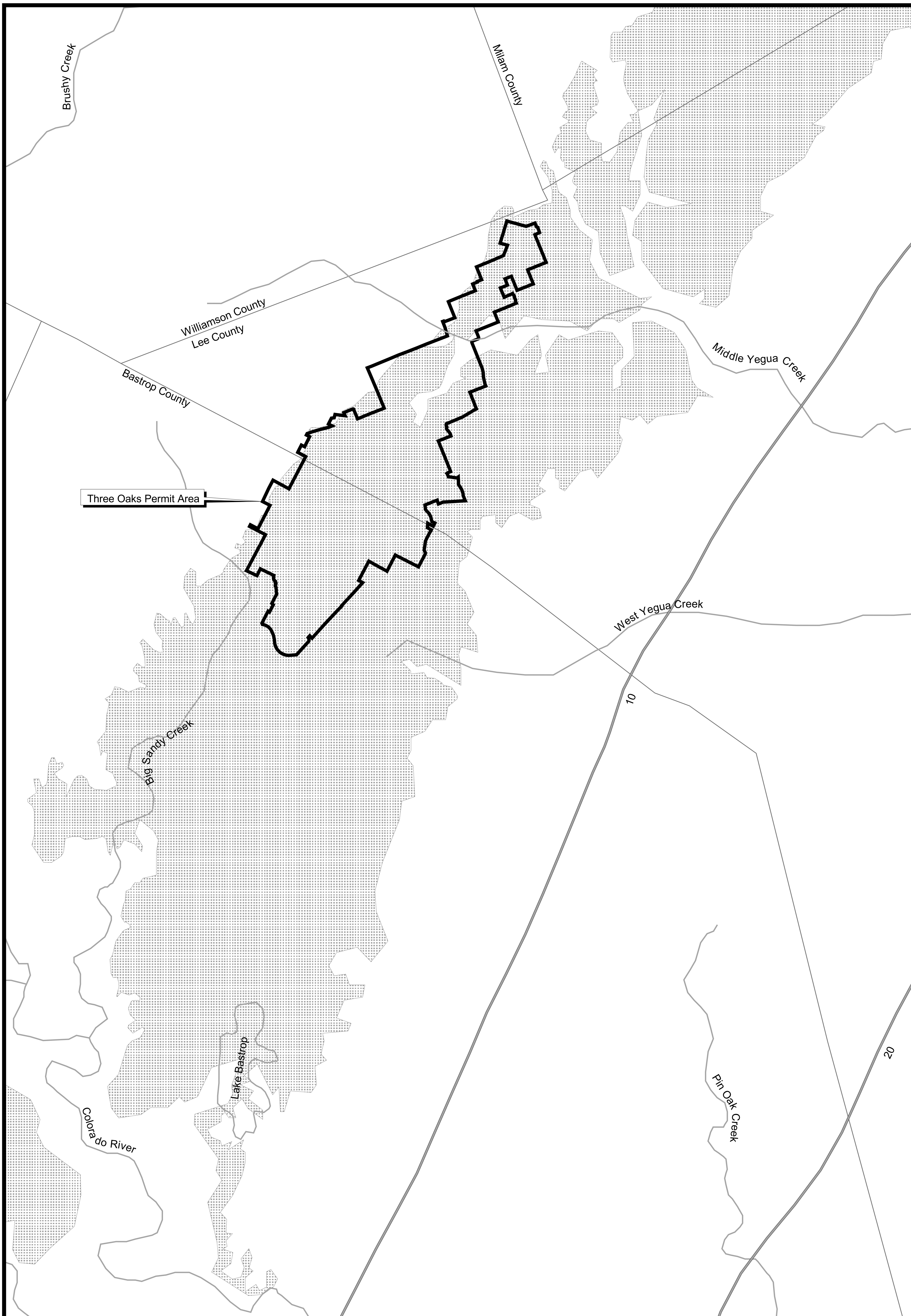
0 1 2 3 4 5 Miles

Source: Drawdown modeled by ENSR 2002.

Three Oaks Mine

Figure 3.2-16
Cumulative Drawdown
in Simsboro Aquifer
Three Oaks
with SAWS Scenario
Year 2050

7/18/02



Approximate Drawdown (10- and 20-foot intervals)
Drainages
Calvert Bluff Outcrop

N

0 1 2 3 4 5 Miles

Source: Drawdown modeled by ENSR 2002.

Three Oaks Mine

Figure 3.2-17
Cumulative Drawdown
in Calvert Bluff Aquifer
SAWS without
Three Oaks
Year 2030

7/18/02

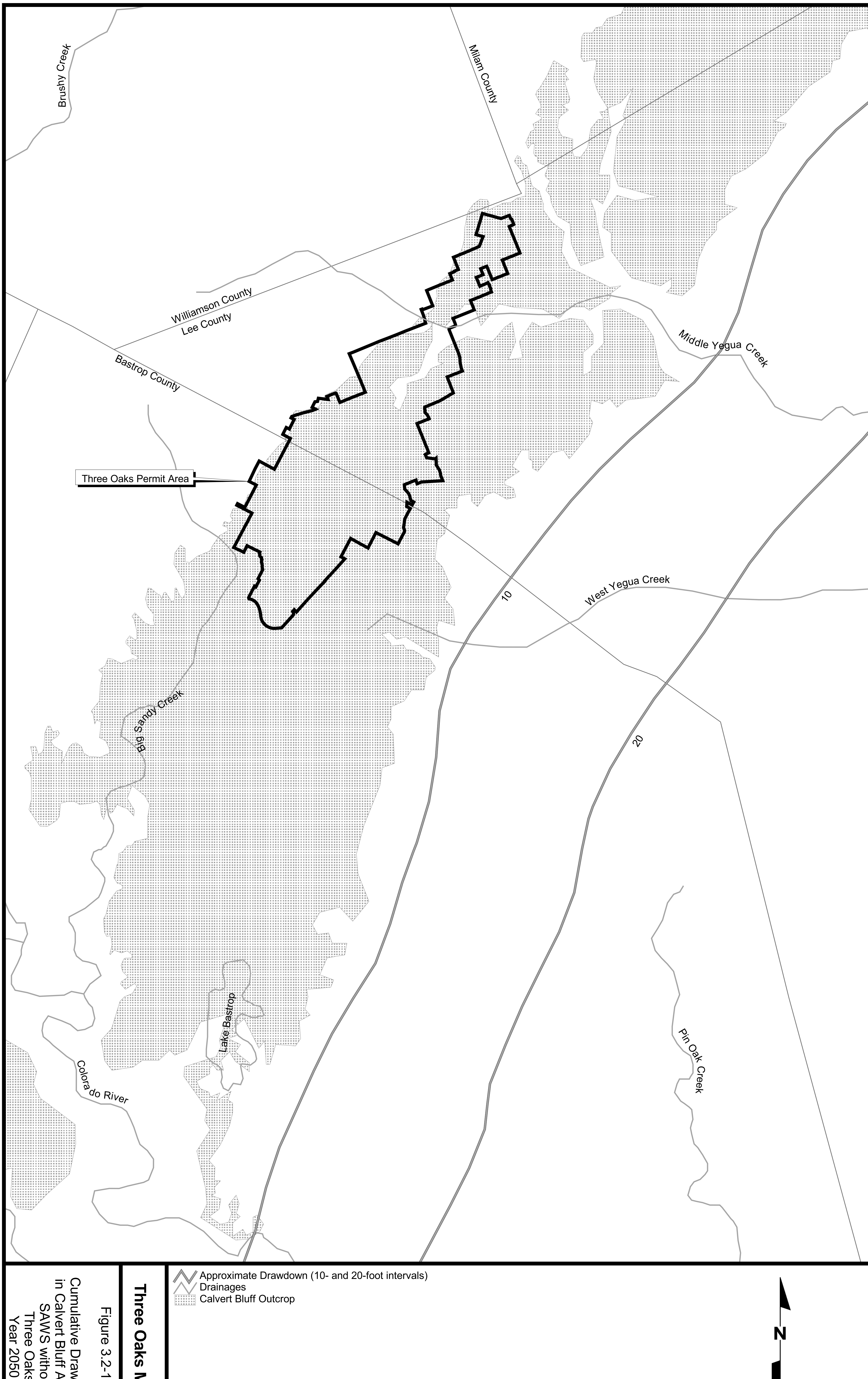


Figure 3.2-18
Cumulative Drawdown
in Calvert Bluff Aquifer
SAWS without
Three Oaks
Year 2050

Three Oaks Mine

Approximate Drawdown (10- and 20-foot intervals)
Drainages
Calvert Bluff Outcrop

N

0 1 2 3 4 5 Miles

Source: Drawdown modeled by ENSR 2002.

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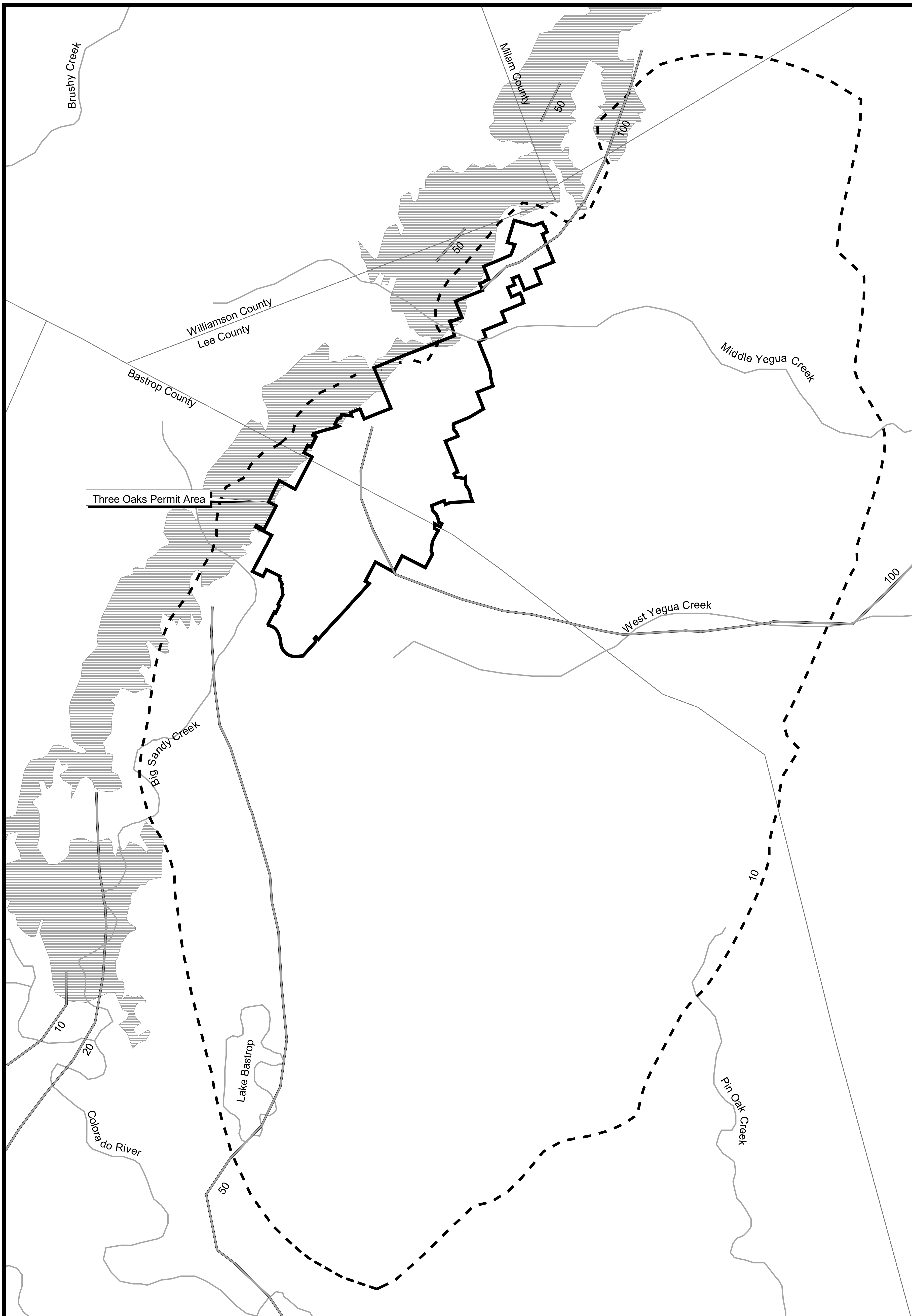

Figure 3.2-19
Cumulative Drawdown
in Simsboro Aquifer
SAWS without
Three Oaks
Year 2030

Three Oaks Mine

Approximate Drawdown (10-, 20-, 50-, and 100-foot intervals)
Approximate 10-Foot Drawdown, Three Oaks Mine Direct Impacts, Year 2030
Drainages
Simsboro Outcrop

N

0 1 2 3 4 5 Miles

Source: Drawdown modeled by ENSR 2002.

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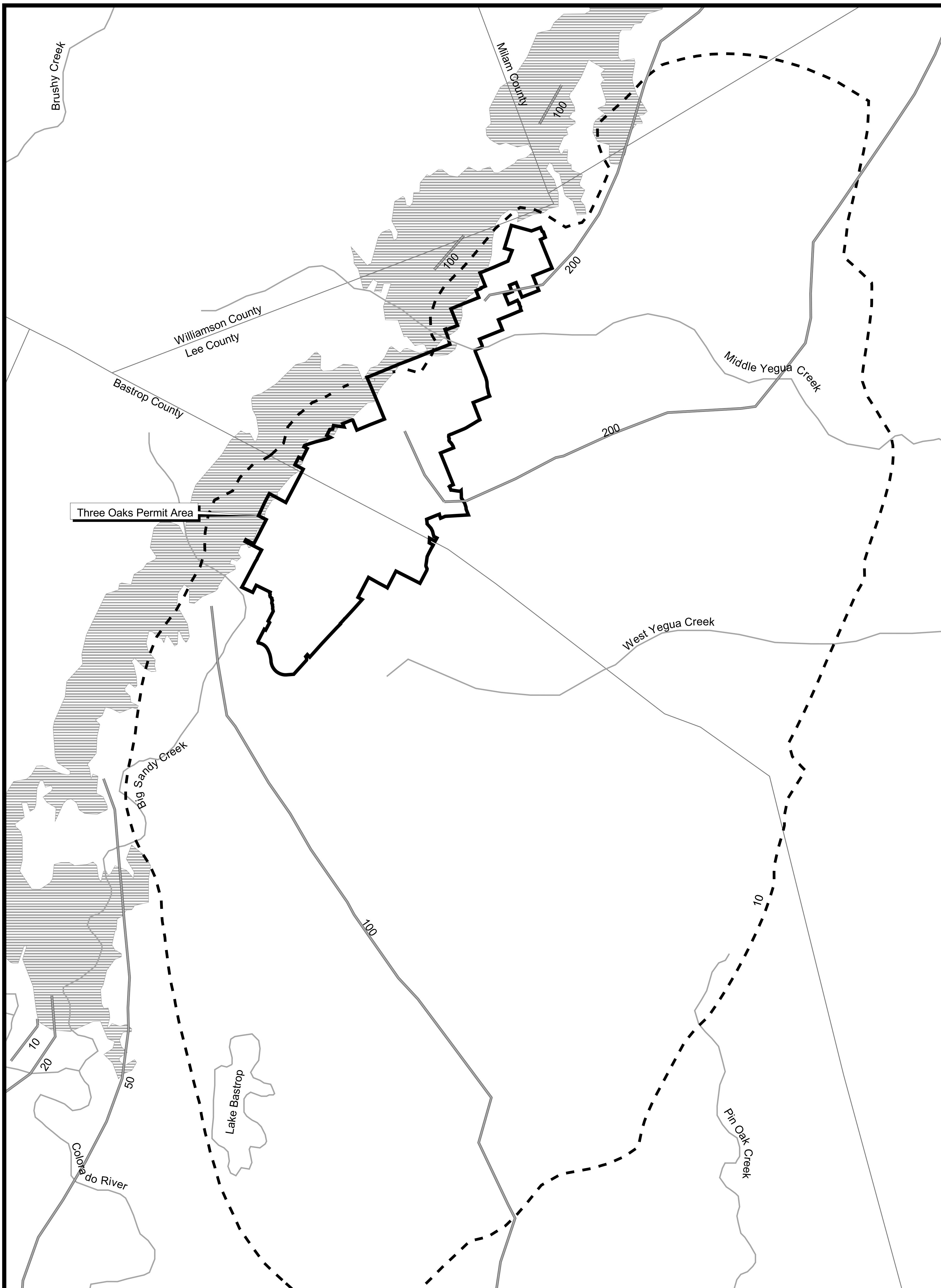


Figure 3.2-20
Cumulative Drawdown
in Simsboro Aquifer
SAWS without
Three Oaks
Year 2050

Three Oaks Mine

Approximate Drawdown (10-, 20-, 50-, 100-, and 200-foot intervals)
Approximate 10-Foot Drawdown, Three Oaks Mine Direct Impacts, Year 2030
Drainages
Simsboro Outcrop

N

0 1 2 3 4 5 Miles

Source: Drawdown modeled by ENSR 2002.

7/18/02

The projected drawdown under this scenario would be slightly greater than under the Three Oaks with SAWS scenario due to variations in SAWS pumpage rates from the Three Oaks site, up to approximately year 2030 (10,000 acre-feet per year versus 15,000 acre-feet per year).

Cumulative Groundwater Quantity Impacts

Cumulative impacts to wells affected by groundwater drawdown would be similar to the direct impacts identified under Groundwater Quantity Impacts in Section 3.2.3.2. Wells within the upper Calvert Bluff aquifer or the 10-foot drawdown area of the Simsboro aquifer are not likely to be affected. Wells within the area between 10 and 20 feet of groundwater drawdown potentially would be affected. Wells in the 20-foot or greater area of groundwater drawdown likely would require mitigation, in accordance with RRC requirements, to ensure continued water supply if completed in the zones impacted.

It should be noted that Three Oaks Mine-related impacts in the cumulative scenarios would be associated with the area within the 10-foot drawdown contour for direct impacts versus the 10-foot drawdown contour for cumulative impacts, which would be the result of SAWS and/or municipal pumpage.

Municipal groundwater pumpage in the counties in the lower basin area of Region G and adjacent counties of Regions H, I, and K is projected to continue into the future. Cumulative impacts of the Three Oaks Mine depressurization pumpage together with this municipal pumpage relative to the direct Three Oaks Mine projected direct 10-foot drawdown contour are shown in **Figures 3.2-11, 3.2-12, 3.2-15, 3.2-16, 3.2-19,** and **3.2-20** for the Simsboro aquifer. Existing regional groundwater levels and projected regional groundwater drawdown associated with regional municipal pumpage, outside the area of potential direct effect of Three Oaks Mine pumpage, are shown in **Figures D-1** through **D-7** in Appendix D for the Carrizo aquifer; **Figures D-8** through **D-14** for the Calvert Bluff aquifer and **Figures D-15** through **D-21** for the Simsboro aquifer.

The Simsboro aquifer is the principal aquifer currently used for municipal groundwater in the Brazos G Regional Water Planning Area and is projected to continue to be the principal aquifer used for the next 50 years. As a result, The Simsboro aquifer water table would continue to decline with time between the years 2000 and 2050 due to increased municipal and other groundwater use in the lower basin area of the Brazos G Regional Water Planning Area (TWDB 2002b).

The regional decline in the water table within the outcrop area of the Calvert Bluff aquifer is expected to be approximately 10 feet or less. This projected decline would not be expected to cause a reduction in recharge to the aquifer.

Cumulative Groundwater Quality Impacts

The cumulative withdrawal of groundwater from the Simsboro and Calvert Bluff aquifers of the Carrizo-Wilcox aquifer system as a result of pumpage under the cumulative scenarios would not affect groundwater quality in the Sandow/Three Oaks Mine area. This determination is based on the hydraulic separation between the Simsboro and Calvert Bluff aquifers, as discussed under Groundwater Quantity Impacts in

Section 3.2.3.2. Groundwater quality in the Simsboro aquifer is good throughout the cumulative effects area. Groundwater quality in the Calvert Bluff aquifer in the cumulative effects area generally is not suitable for domestic use.

3.2.3.4 Monitoring and Mitigation Measures

GW-1: Baseline Monitoring. Groundwater level monitoring would begin in the Simsboro outcrop area to the west of the Three Oaks Mine at least 1 year prior to the commencement of groundwater pumping. The outcrop area encompassed by the mine-related 10-foot or greater drawdown would be monitored. This would provide documentation of baseline conditions for future use in assessing mine-related groundwater drawdown impacts as defined by the Three Oaks groundwater model, and the potential subsequent need for Alcoa to modify or replace existing private wells in accordance with RRC regulations.

GW-2: Operational Well Monitoring. Groundwater levels in the Calvert Bluff and Simsboro aquifers would be monitored on a quarterly basis, beginning at least 1-year, if possible, prior to commencement of dewatering and depressurization operations at the Three Oaks Mine. Monitoring well locations would be selected based on: 1) access and land ownership, 2) screened interval of the pumping wells relative to the monitored aquifer, 3) spatial distribution relative to the pumping wells and position within the projected 10-foot drawdown contour for the aquifer, and 4) experience gained in monitoring drawdown impacts at the Sandow Mine. At least five monitoring wells for the Simsboro aquifer would be located in the Simsboro outcrop area to the west of the Three Oaks Mine. These five monitoring wells would encompass the projected range of drawdown in the Simsboro outcrop area out to the projected 10-foot drawdown contour, as presented in Alcoa's RRC permit application, Section .146. A preliminary set of monitor wells also is presented in the RRC permit application in Section .146. For the outcrop area of the Simsboro aquifer, monitor wells would be added to this preliminary list and installed as needed based on landowner permission. Groundwater level and groundwater quality monitoring would comply with RRC guidelines.

Monitoring would be on a quarterly basis for the first 5 years of operation of the Three Oaks Mine. Groundwater monitoring reports would be submitted to the USACE and the RRC annually. At the end of the first 5 years of operation, the Three Oaks LOM Model developed by Alcoa for the Three Oaks Mine would be validated against the observed drawdown in both the Calvert Bluff and Simsboro aquifers. The results of this validation would be supplied to the USACE and the RRC. The Three Oaks LOM Model then would be recalibrated based on the 5-year drawdown data, and projections for the drawdown out to the 10-foot drawdown contour would be made for the remaining life of the mine. A report detailing the recalibration and new projections for the drawdown contours would be submitted to the USACE and RRC.

Following the first 5 years of operation, groundwater monitoring in the Calvert Bluff and Simsboro aquifers would be conducted on a semi-annual basis. Reports would be submitted to the USACE and the RRC on an annual basis. The Three Oaks LOM Model would be validated against observed drawdown every 5 years, and the results of the validation would be submitted to the USACE and RRC. The groundwater model would be recalibrated as needed every 5 years, and projections for drawdown out to the 10-foot drawdown contour would be made for the estimated remaining life of the mine. These projections would be submitted to the USACE and RRC in a modeling report.

The position of the projected drawdown contours for the Calvert Bluff and Simsboro aquifers would be used as a guide to determine the potential mine-related impacts of dewatering and depressurization operations on private and municipal wells in these two aquifers near the Three Oaks Mine. These projections would be updated every 5 years based on recalibration of the Three Oaks LOM Model to observed drawdown in these two aquifers.

3.2.3.5 Residual Adverse Effects

There would be temporary residual adverse effects to groundwater quantity as a result of Three Oaks Mine pumping, pending the recovery of groundwater levels in the Simsboro aquifer approximately 40 to 100 years post-mining. The groundwater level in the Simsboro aquifer is anticipated to recover to 90 percent of its pre-mining level in approximately 40 years and to 100 percent in approximately 100 years (Alcoa 2000 [Volume 10]). These estimates appear to be reasonable.

3.2.4 Surface Water

3.2.4.1 Affected Environment

Regional Surface Water Features

Major components of the surface water network in the study area include the Lower Colorado River to the southwest, Somerville Lake to the east, and several streams that transect the region. The latter include Brushy Creek, West Yegua Creek, Middle Yegua Creek, East Yegua Creek, Big Sandy Creek, and numerous tributaries (**Figure 3.2-21**). The study area for surface water resources includes these drainages within the permit area and the projected mine-related 10-foot groundwater drawdown areas within the Simsboro and Calvert Bluff aquifer outcrops, extending downstream to Somerville Lake and the Colorado River at Bastrop, Texas. The cumulative effects area includes these drainages within the permit area and the interrelated actions' projected 10-foot groundwater drawdown areas within the Simsboro and Calvert Bluff aquifer outcrops, extending downstream to Somerville Lake and the Colorado River. Seven USGS stream gages are present within the study area. These are shown in **Figure 3.2-1**, and their mean annual flows are shown in **Table 3.2-7**. Mean monthly flow data for these stations are shown in **Table C-6** in Appendix C.

Monthly streamflow varies substantially at all of the gages in the area. The stream gage on Middle Yegua Creek near Dime Box exemplifies this, as shown in **Table C-7** in Appendix C. Conditions of very low to zero flow often occur in late summer and early fall at this station. Late-season low-flow to zero-flow conditions also exist in most streams in the region. In contrast to Middle Yegua Creek, periods of zero-flow are rare at the USGS gage on East Yegua Creek near Dime Box. Both streams historically have been augmented to some degree by pumping discharges from the Sandow Mine. However, these discharges occur approximately 20 miles upstream of the USGS gages, and channel losses are substantial in the area.

It is not known to what degree the higher late-season flows in East Yegua Creek reflect mine discharges, topographic differences, other man-made sources, or groundwater contributions. It is likely that mine discharges have augmented the flows in both channels, and particularly on East Yegua Creek as a result of

Table 3.2-7
Mean Annual Flow at USGS Stream Gages in the Project Region

USGS Gage Name	Gaging Station Identifier	Period of Record (as currently published)	Contributing Area (square miles)	Mean Annual Flow/Area (cfs per square mile) (for period of record)
Brushy Creek near Rockdale	08106300	8/67 – 9/80	505	0.39
Big Sandy Creek near McDade[1]	08159165	7/79 – 9/85	38.7	0.22
Big Sandy Creek near Elgin[1]	08159170	7/79 – 9/85	63.8	0.16
Middle Yegua Creek near Dime Box	08109700	8/62 – 9/00	236	0.24
East Yegua Creek near Dime Box	08109800	8/62 – 9/00	244	0.26
Yegua Creek near Somerville	08110000	6/24 – 9/91	1,009	0.28
Colorado River at Bastrop	08159200	3/60 – 9/00	28,576	0.08

[1]The USGS station on Big Sandy Creek near McDade is upstream of the station near Elgin.

Source: USGS 2001.

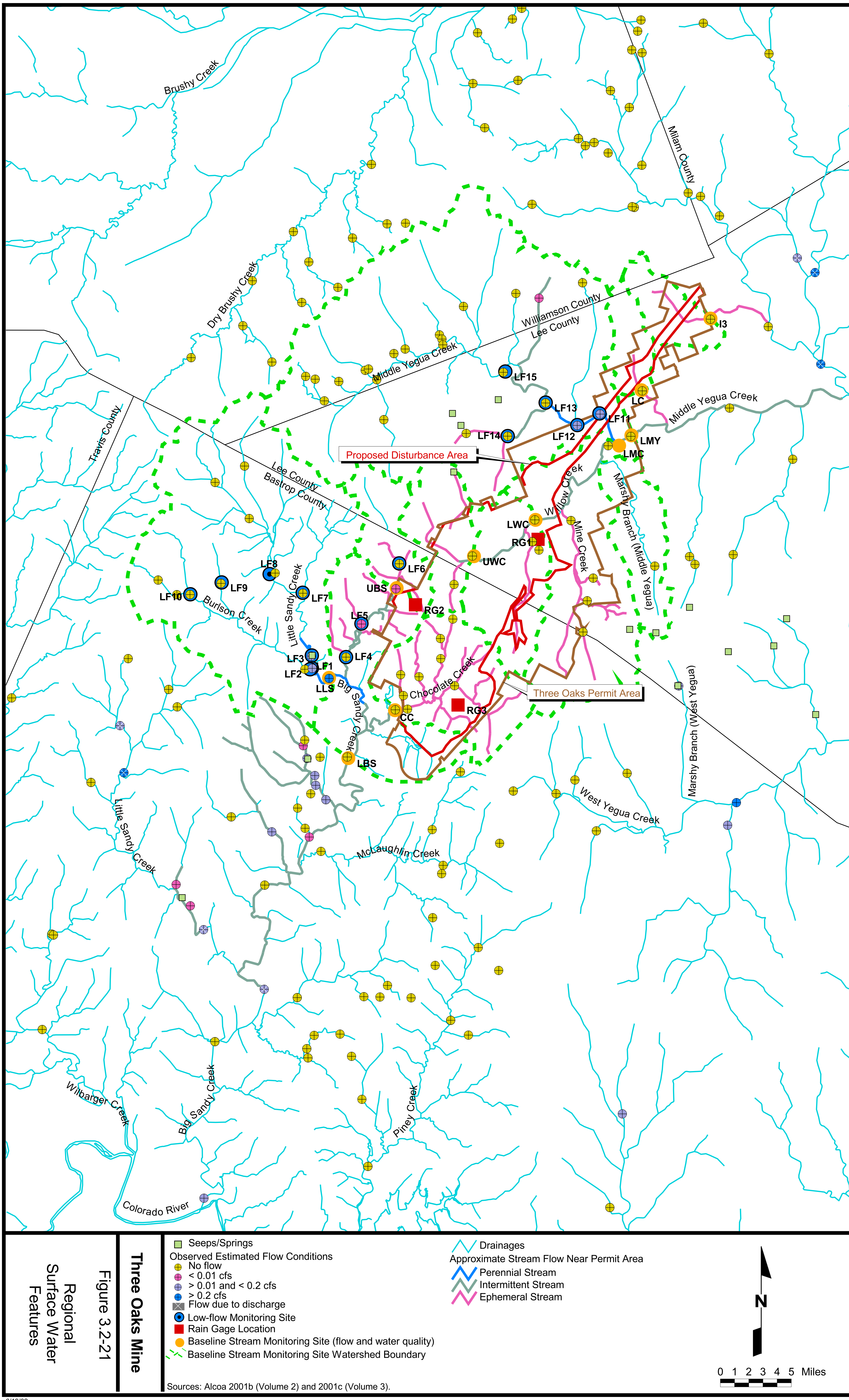
pumping from the northern portions of the Sandow Mine. Approximate Sandow Mine discharges have been estimated as shown in Appendix C, **Table C-8**.

During large precipitation events, the flows in regional channels rise rapidly. For example, in sharp contrast to the average flows, the peak annual flows for Middle Yegua Creek near Dime Box have frequently been on the order of 2,000 to 6,000 cubic feet per second (cfs). In May 1975 and during the December 1991 storm event, the recorded peak flows were 11,400 and 12,500 cfs, respectively. Consistent with the wide variation characteristic of the region, a number of annual peak flows at the station are less than 1,000 cfs and some are less than 100 cfs (USGS 2001).

It should be noted that flows in the Colorado River at Bastrop are particularly influenced by storage and release schedules on large reservoirs upstream and by numerous diversions. Also of note is the lower flow per unit watershed area along Big Sandy Creek from the USGS gage near McDade downstream to the USGS gage near Elgin.

Major reservoirs in the region include Somerville Lake, a USACE project near Somerville; the Highland Lakes on the Colorado River above Austin; and Lake Bastrop on a tributary to Piney Creek near the City of Bastrop. The Highland Lakes, the largest of which are Lake Travis, Lake LBJ, and Lake Buchanan, are located outside of the study area; however, they have substantial effects on flow and water use in the Lower Colorado River. Lake Bastrop also is located in the Lower Colorado River drainage and is outside of the study area.

Located on Yegua Creek, Somerville Lake began impounding water in January 1967. It has a total storage capacity of 337,700 acre-feet, and it controls approximately 76 percent of the Yegua Creek drainage. The lake provides flood protection for approximately 9,000 acres along lower Yegua Creek, and assists in flood protection and irrigation of 887,000 acres along the Brazos River. The pool elevation is maintained at 238 feet to the extent possible, and the spillway crest elevation is at 258 feet. One hundred percent of the conservation storage (143,900 acre-feet) below elevation 238 feet is contracted to the Brazos River Authority. Recent storage at Somerville Lake has ranged from 368,101 acre-feet in November 1998 to



Three Oaks Mine

Figure 3.2-21
Regional Surface Water Features

6/19/02

101,584 acre-feet in October 2000. More typically, recent storage has been approximately 130,000 to 160,000 acre-feet (USACE 2001).

Local Surface Water Features

Within and near the proposed mine permit area, the major drainages include Middle Yegua Creek (in the Brazos watershed) and Big Sandy Creek (in the Colorado watershed). Local tributaries to Middle Yegua Creek include Willow Creek, Mine Creek, and Marshy Branch. Burlson Creek, Little Sandy Creek, and Chocolate Creek are tributaries to Big Sandy Creek. These local area streams are shown in **Figure 3.2-21**. Near the permit area, creeks and streams are generally classified as intermittent with some ephemeral segments. TNRCC has classified Middle Yegua Creek as intermittent with perennial pools. TNRCC has tentatively classified all other tributaries within the permit area as intermittent with no perennial pools (Davenport 2001).

Stream channels in the permit area have average main channel gradients ranging from approximately 10 to 50 feet per mile. Channel cross-sections are typically incised, with eroded cutbanks transitioning to flatter adjoining floodplains and overbank terraces. Bank material grain sizes range from clays to gravels depending on site-specific geologic formations (both underlying and upstream) and in-channel flow velocities (Alcoa 2000 [Volume 5]). Channel banks typically are vegetated and are considered stable with only minor erosion occurring at some locations.

Alcoa is conducting a flow measurement and sampling program on streams in and near the permit area (Alcoa 2000 [Volume 5]). RRC regulations require a minimum program duration of 1 year for a surface coal mining permit application. Alcoa's program has been ongoing since late April 1999. **Figure 3.2-21** shows the monitoring locations for streamflow measurements and water quality sampling. The designated locations are identified in **Table 3.2-8**.

Table 3.2-8
Local Stream Monitoring Sites

Station Identifier	Location
UBS	Upper Big Sandy Creek
LBS	Lower Big Sandy Creek
LLS	Lower Little Sandy Creek just above confluence with Big Sandy Creek
LMC	Lower Mine Creek
UWC	Upper Willow Creek
LWC	Lower Willow Creek at County Road 304
CC	Chocolate Creek
LMY	Lower Middle Yegua Creek at County Road 306
LC	Drainage at County Road 309
I3	Sand Branch - tributary to Cross Creek

Source: Alcoa 2000 (Volume 5).

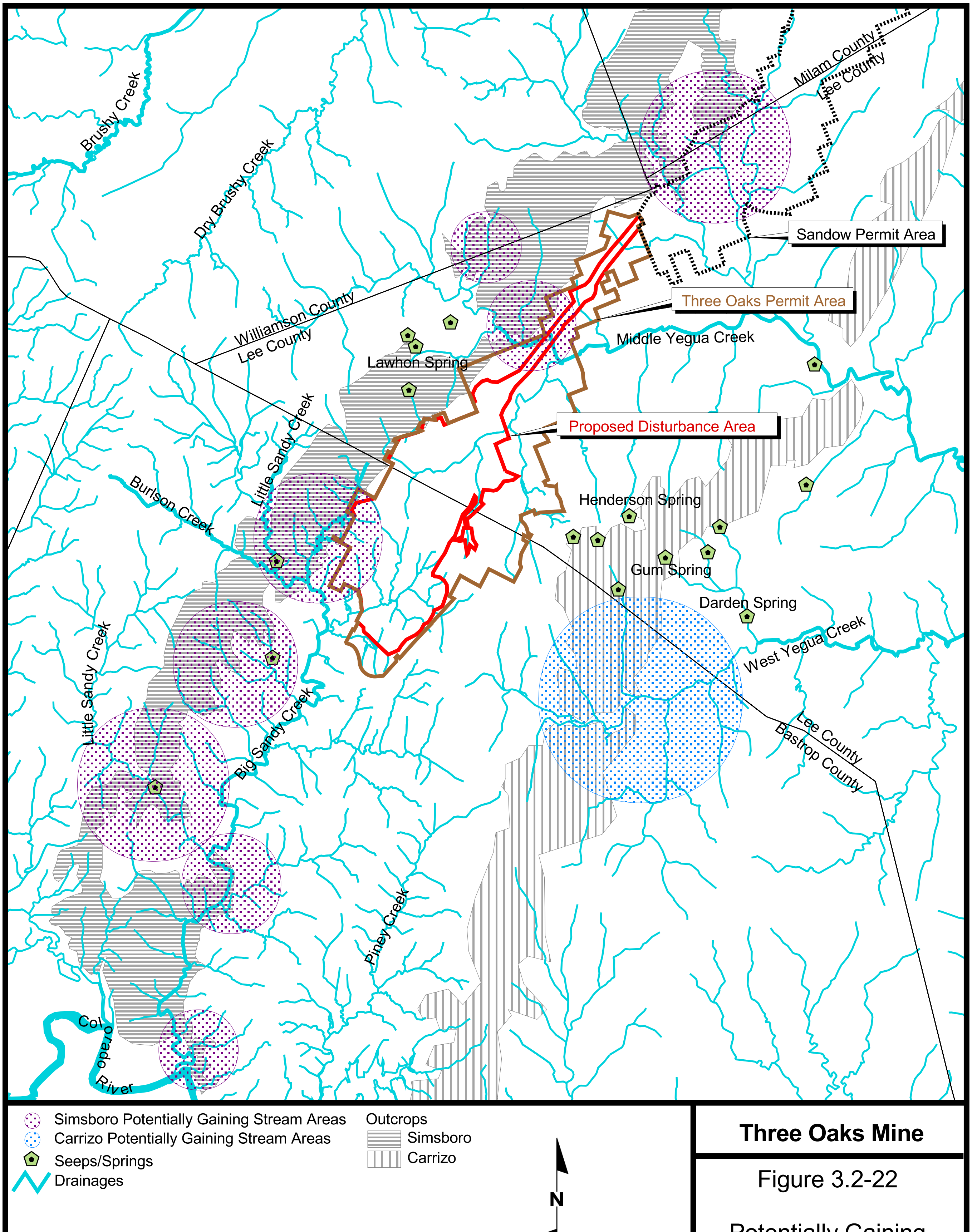
Flow data for these stations are shown in **Table C-9** in Appendix C. The streamflow measurements indicate that Willow Creek, Mine Creek, and Chocolate Creek are dry most of the time and exhibit little sustained flow. This condition generally indicates that flow in these streams is driven primarily by precipitation events.

This separation from groundwater influence may occur as a result of streambed location above the local groundwater levels, or due to the presence of low-permeability materials that serve to isolate the channels. Either of the two conditions would act in combination with high evapotranspiration demands to limit baseflow. Higher sustained flows were recorded on Big Sandy, Little Sandy, and Middle Yegua Creeks. These streams drain larger watershed areas, which extend onto baseflow-contributing areas overlying the Simsboro aquifer outcrop (Alcoa 2000 [Volume 5]).

Low-flow period investigations were conducted at selected locations along Little Sandy, Big Sandy, and Middle Yegua Creeks and associated tributaries (**Figure 3.2-21**) during the latter half of 1999. Flow measurements are presented in **Table C-9** in Appendix C. The measurements indicate that parts of Little Sandy, Big Sandy, and Middle Yegua Creeks receive groundwater contributions over short segments associated with the Simsboro aquifer outcrop. These short reaches are shown within circled areas on **Figure 3.2-22**. In the upper reaches of Big Sandy Creek, numerous ponds exist that may be contributing seepage to a short reach of the channel. Along all three streams, conditions of zero-flow and dry streambeds were identified within short distances of the gaining segments. Immediately downstream of the proposed permit area, both Big Sandy Creek (site LBS) and Middle Yegua Creek (site LMY) showed zero-flow conditions during the late summer and fall of 1999 (**Figure 3.2-21**). Site LBS is at the location of the discontinued USGS gage 08159165 (Big Sandy Creek near McDade). The USGS data from the early 1980s also showed periods of little or no flow at site LBS during the late summer and early fall (August and September), but consistent with the large precipitation and streamflow variability in the region, there also are periods of higher flows in July, October, and November. Such flow variations also are exhibited from year to year in the baseline inventory data collected for Alcoa.

High-flow period investigations were conducted at measurement sites LMY and LBS (**Figure 3.2-21**). These sites had the largest flows recorded during the data collection program. Crest-stage gages were employed for this part of the investigation. At site LMY, the largest flow estimated was 15.5 cfs. At site LBS, the largest recorded flow was 10.64 cfs. Both flows occurred in late January 2001. Typically, flows at these sites are much smaller (frequently less than 1 cfs), and both creeks showed zero flow at these stations in the late summer and early fall of each year.

It should be noted that the water resources inventory for the proposed project has been conducted during drier than average years; somewhat anomalous conditions may be unavoidable in sampling a natural hydrologic system over a limited period. In 1999, rainfall in the area was approximately 60 percent of the long-term average. Streamflows in 1999 at the USGS gages on Middle Yegua and East Yegua Creeks were approximately 50 and 60 percent of their long-term averages, respectively. Available data appear to indicate a dry year at these gages for the year 2000 as well. Therefore, when referring to project area conditions, the use of the terms “average” precipitation or “average” streamflow should be employed with caution. Historically, extreme flow variability has been the natural condition throughout the region. It is probable that streamflows in and near the proposed permit area have somewhat larger magnitude and duration in most years. The duration of isolated channel pools also may be longer in most years. However, for relatively



Sources: Springs: Alcoa 2001b (Volume 2) and USGS 24K topoquads; Potentially gaining stream areas: Alcoa 2001b (Volume 2) and ENSR depth to groundwater analysis.

Three Oaks Mine

Figure 3.2-22

Potentially Gaining Stream Areas and Seep/Spring Locations

7/22/02

undisturbed channels (those that do not convey artificially augmented flows) in the region, these streams have historically exhibited flow in close response to precipitation and frequently have little or no flow in late summer and early fall.

Several springs exist near the permit area, approximately 5 miles northeast of McDade in the Middle Yegua and West Yegua Creek drainages. These include Henderson Spring, Gum Spring, and Darden Spring. Approximately 3 miles farther northeast, an additional unnamed spring occurs adjacent to Middle Yegua Creek, well east of the permit area. All of these springs are located in areas near the Calvert Bluff-Carrizo outcrop boundary. Lawhon Spring is located approximately 0.5 mile northwest of the permit area, near the Hooper-Simsboro outcrop boundary, slightly east of the intersection of the Bastrop-Lee-Williamson County lines. Flow amounts and durations at these locations are unknown, but are likely to be small and intermittent.

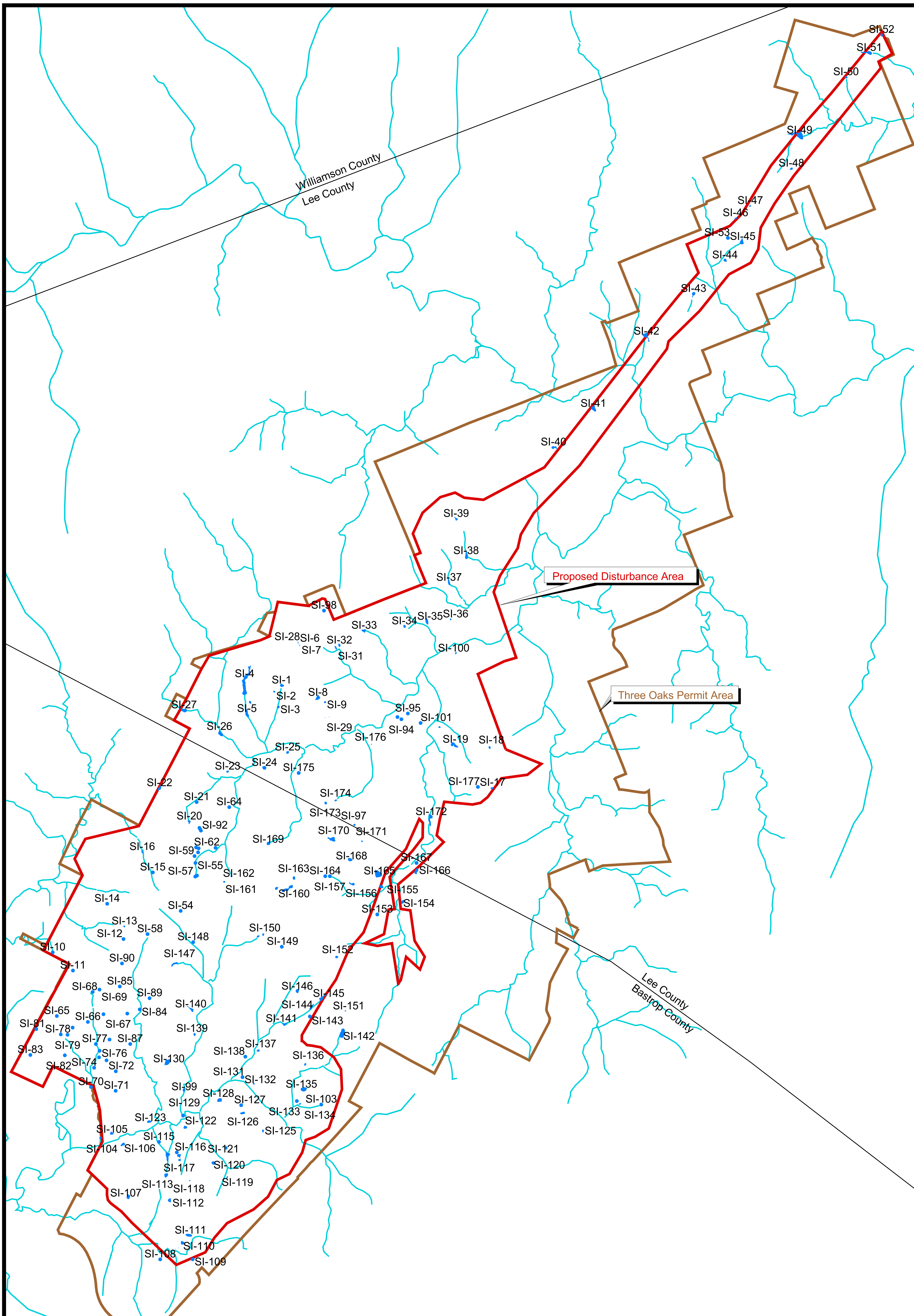
Numerous stock ponds of varying sizes occur within the study area and within the proposed permit area. Over 100 stock ponds occur in the proposed permit area, as shown in **Figure 3.2-23**. The density of stock pond occurrence varies substantially in the region, and it appears to be on the order of 5 to 10 ponds per square mile. Most of these ponds have been placed in small tributary drainageways and are supplied by surface runoff. The water levels in these ponds vary throughout the year, with many exhibiting substantial or complete drawdown during droughts. In addition, seeps or wet depressions are distributed throughout the region and in the permit area. These features are typically located in small tributary drainageways; however, many occur on hillslopes or are associated with larger stream channels. Additional description of the distribution of USACE jurisdictional features is presented in Section 3.2.5, Waters of the U.S. Including Wetlands.

Regional Surface Water Quality

TNRCC administers surface water quality regulatory programs in Texas, with substantial involvement from river authorities (such as the LCRA and the Brazos River Authority) and other state and local groups. Activities by these organizations include those conducted under the Texas Clean Rivers Program and other enabling legislation. Groundwater quality is described in Section 3.2.3.1, Groundwater. Surface water quality regulations, standards, criteria, and their application have been promulgated in TAC, Title 30, Chapter 307 (TAC 2000a). Drinking water standards are addressed in TAC Title 30, Chapter 290 (TAC 2000b). In addition, the Colorado River Watershed Protection Rules (30 TAC 311E) (TAC 1986), TPDES permit requirements, and the 401 Certification process also apply to activities that may affect water quality.

Four general categories of use are identified for Texas surface water quality standards. These include aquatic life use, contact recreation, public water supply, and fish consumption. Revised TNRCC regulations provide surface water quality provisions (including anti-degradation) to habitat for aquatic life uses, wetland water quality functions, and discharge of dredged or fill material under Section 401 of the CWA.

No stream reaches within the study area are listed in the Texas CWA Section 303(d) list of water bodies that do not meet, or are not expected to meet, water quality standards (TNRCC 2000). According to 30 TAC 307, two classified stream segments exist within the region. These include the Colorado River above LaGrange (Segment 1434) and Somerville Lake (Segment 1212) in the Brazos River basin.



Inventoried Pond

N

0 1 Miles

Source: Alcoa 2001c (Volume 3).

Three Oaks Mine

Figure 3.2-23
Surface Water Impoundments

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Site-specific water quality criteria as listed in 30 TAC 307 apply to these segments. Other streams, including East and Middle Yegua Creeks and Big Sandy Creek, are unclassified. Water quality criteria for Segments 1434 and 1212 apply as default criteria for the non-designated stream segments in their respective basins. **Table C-10** in Appendix C indicates surface water criteria for classified stream segments. **Table C-11** in Appendix C indicates surface water criteria for selected toxic constituents for the Brazos and Colorado River basins.

The USGS has conducted water quality sampling in the vicinity of stream gages on East Yegua Creek (Station 08109800), Big Sandy Creek near McDade (Station 08159165), and Big Sandy Creek near Elgin (Station 08159170) (see **Figure 3.2-1**). Alcoa has conducted additional water quality sampling in the vicinity of the existing Sandow Mine as part of monitoring programs for that facility. Regional sampling results generally indicate good water quality, with constituent levels typically within general criteria for the uses.

In general, levels for both total and dissolved metals and metalloids (non-metallic elements having some of the chemical properties of metals) are below detection limits at all USGS and privately monitored sites, with the exception of iron, barium, and manganese. Where trace metals were detected, their amounts were often below drinking water standards (Alcoa 1999). Additional detail regarding regional surface water quality is provided in Appendix C.

<u>Local Surface Water Quality</u>

On a preliminary basis, TNRCC has categorized Middle Yegua Creek, a stream within the permit area boundary, as being intermittent with perennial pools (Davenport 2001). All other tributaries within the permit area appear to be intermittent with no perennial pools (Davenport 2001). In general, an intermittent stream is defined by TNRCC as “a water body that has measurable flow only intermittently in an annual cycle, such that the stream flows for only a few weeks or months during a given year, depending on contributing discharges to the stream, such as rainfall or groundwater” (TNRCC 1999).

A more specific definition is given with regard to water quality standards in 30 TAC Part 1, Chapter 307, Rule 307.3, where an intermittent stream is defined as “a stream which has a period of zero flow for at least 1 week during most years. Where flow records are available, a stream with a 7Q2 flow of less than 0.1 cubic feet per second is considered intermittent”. A 7-day, 2-year low-flow (7Q2) flow is the lowest average stream flow for 7 consecutive days with a recurrence interval of 2 years, as statistically determined from historical data. As specified in 30 TAC Part 1, Chapter 307, Rule 307.8, some water quality standards do not apply at stream flows, which are less than the 7Q2 flow. Rule 307.3 also defines an intermittent stream with perennial pools as being an “intermittent stream which maintains persistent pools even when flow in the stream is less than 0.1 cubic feet per second.”

Resource values, in the form of beneficial uses of surface water, are associated with the TNRCC stream classifications described above. In accordance with 30 TAC 307.4(h)(4), Middle Yegua Creek is assumed to have limited aquatic life use (a regulatory classification with attendant water quality standards). The remaining streams are assumed not to have a regulatory classification involving aquatic life uses. For the project area, these stream classifications may be revised pending further TNRCC review (Treviño 2001). Additional information is available from the surface water inventory conducted for the project area in response to RRC regulations (Alcoa 2000 [Volume 5]). Results of flow monitoring investigations indicate that relatively short perennial reaches probably exist in isolated locations on Big Sandy and Middle Yegua Creek, longer reaches having intermittent flow conditions exist on these streams and some tributaries, and ephemeral conditions are widespread, being typical on most tributaries (see **Figure 3.2-21**). Ephemeral streams flow only in direct response to rainfall/runoff events. In the project region, flow is sustained in such drainages only for short periods, usually a matter of hours or days.

Alcoa has developed a surface water control plan and a monitoring plan for the proposed project. In addition, regulatory processes are required that involve the USACE, TNRCC, and RRC in the review and approval of permit applications and related control measures for surface drainage, discharge, and water quality. The applicability of specific water quality standards and detailed approaches to compliance will be determined during these processes. Compliance monitoring and reporting would be conducted during operations and for a subsequent period to be determined. Review of the permits and practices would be conducted every 3 years as part of the continuing regulatory program. This assessment of potential impacts to surface water resources considers these factors.

Alcoa has conducted surface water quality inventories in the proposed permit area and adjacent downstream areas for the RRC Three Oaks Mine Permit Application. The water quality sampling locations are identified in **Table 3.2-8**. Water quality from the local area inventory generally corresponds to that described for the region. Sampling results from the local area inventory are shown in **Table C-12** in Appendix C. Total and dissolved metals and metalloids were generally below detection limits and within general criteria when detected. Hardness and TDS varied widely. Chloride and sulfate levels were slightly elevated above regional values in some instances, particularly along Chocolate Creek, Lower Big Sandy Creek, Lower Mine Creek, and Lower Middle Yegua Creek. With few exceptions (notably in February 2001), dissolved oxygen levels were generally acceptable throughout the year for limited aquatic life use (TAC 2001a). The major exception is at Upper Big Sandy Creek (Site UBS) where dissolved oxygen levels were lower. Flow rates at this site are quite low and may be associated with natural groundwater discharge into the channel.

Alcoa has inventoried the majority of the surface water impoundments within the area proposed for mining (Alcoa 2000 [Volume 5]). Sampling results from this inventory are shown in **Tables C-13** and **C-14** in Appendix C. Generally, the water in the surface impoundments was of good quality and suitable for most uses. In some instances, the pH exceeded commonly accepted limits; however, it was generally between 6 and 9 standard units. Specific conductivity was generally lower than stream values during low-flow periods and was generally considerably less than in groundwater from the surrounding Calvert Bluff Formation. This difference would further corroborate the likelihood that most water in the surface impoundments has its origin in surface runoff. Where higher conductivities were identified, they are likely to result from groundwater inflows, evapoconcentration, or from reaction to adjacent geologic strata.

Erosion and Sedimentation. USGS water quality sampling on area streams has included suspended sediment measurements and allows general characterization of erosion and sedimentation in the study area. Particle-size distributions evaluated in the sampling program indicate that most of the suspended sediment consists of clay, with much smaller percentages of silt and sand. This is typical of most suspended sediment measurements, and does not include bedload transport (movement of gravel and sand along the bottom of the channel). Finer sediment particles are usually suspended in the streamflow resulting in a turbid appearance, particularly during larger runoff events. Coarser particles, consisting of sand and gravel, are usually moved along the channel bed by the tractive force of the overlying flow. These coarser materials are not generally accounted for in suspended sediment samples. Annual suspended sediment yields measured by the USGS are approximately 0.3 to 0.45 ton per acre, as a rate delivered past the gage from the watershed. Over the long term, the total amount of sediment delivered past the gage is likely to be somewhat greater when coarser bedload materials are included, particularly if higher flows have not activated the channel bed and banks during the sampling program.

Recently, the TWDB and USACE, Fort Worth District, have worked together to identify the remaining storage capacities of regional reservoirs. After years of operation, the available storage capacity of some reservoirs may be diminished by sediment infilling, whereas other reservoirs may be relatively unaffected. The TWDB surveys for Somerville Lake in the lower Yegua Creek drainage were concluded in 1995 (TWDB 2001b). The survey results indicate that approximately 3.2 percent of the conservation pool capacity has been lost from sediment infilling since the start of water impoundment in January 1967. Given the pool capacities, the dates of data collection, and the contributing drainage area (1,006 square miles), it can be calculated that on average approximately 0.65 ton per acre per year of sediment were delivered to Somerville Lake from the Yegua Creek watershed. Since no major land use or climatic changes are known to have occurred in the watershed, this value may be interpreted as an average annual sediment yield for the region, with the Yegua Creek watershed being the source of supply.

Additional erosion analyses were conducted for the proposed permit area using the RUSLE. This approach estimates rill and gully erosion from a particular plot of land, based largely on empirical input factors that are estimated from available topography, vegetation, soils, and rainfall data. These investigations indicate an average annual soil loss of approximately 0.12 ton per acre. It should be noted that the RUSLE provides an estimate of gross erosion, rather than sediment yield, from rill and gully erosion. The results are best used for comparative purposes of landscape stability, rather than as absolute numerical interpretations, unless extensive calibration of the input has been conducted in an area. The actual sediment yield from rill and gully erosion factors is likely to be less than the RUSLE calculation on an average annual basis, since much of the material eroded remains stored (deposited) elsewhere within the watershed. Furthermore, over a limited sampling period, the actual sediment transport rate past a stream gage may differ significantly from gross erosion estimates, since large volumes of sediment are stored in alluvial terraces and channels and only are transported during larger flow events. Substantial sediment transport rates do occur in local and regional streams during high flows, as documented in USGS data described previously. Since the stream gages are in headwaters or higher tributaries, most of the sediment transported in local area streams has originated from nearby land surfaces.

Surface Water Uses and Discharges

Reviews of existing surface water rights in the study area indicate that a number of rights and uses exist in the area and in nearby portions of the area watersheds, as shown in **Tables C-15** through **C-17** in Appendix C. Major surface water rights are held by the City of Brenham, Brazos River Authority, LCRA, Alcoa, and numerous individuals along the Colorado River. Major users include Alcoa, the LCRA, and the

Cities of Rockdale and Lexington (Alcoa 2000 [Volume 5]). In addition, a large number of surface impoundments are located on lands owned by CPS; these are identified in **Table C-14**.

3.2.4.2 Environmental Consequences

Proposed Action

Surface Water Quantity Impacts.

Removal of Surface Water Features. A total of approximately 38 miles (23.6 acres) of existing intermittent and ephemeral streams would be removed through mining or recontouring in the proposed project area. This disturbance would occur incrementally over the life of the mine. The majority of these features (approximately 19.9 acres) consist of small ephemeral drainages that flow only in direct response to rainfall/runoff events. Of the intermittent streams (approximately 3.7 acres), approximately 2,000 feet of Chocolate Creek and 10,000 feet of Willow Creek would be disturbed within the proposed disturbance area. In the mine area, the disturbance or removal of stream channels would be temporary impacts, since drainage features ultimately would be restored during reclamation. In addition, many stream channels would be rerouted during mining, rather than being completely removed. During the active mining period, streams that flow onto the mine area from upstream locations would be rerouted around the disturbance areas or routed through them in clean-water diversions. No direct disturbance would occur on Big Sandy Creek or Middle Yegua Creek, except as needed for access corridor crossings, which are discussed below. After final recontouring, runoff and streamflows from approximately 9,800 acres of watershed area would be routed into end lakes.

Approximately 150 stock ponds occupying approximately 69.9 acres would be removed by mining. Of this total pond area, approximately 38.5 acres are on-channel ponds considered to be waters of the U.S. The remaining 31.4 acres consist of non-jurisdictional stock ponds. The removal of stock ponds would create temporary impacts, since restoration of similar features within the project area would occur incrementally during concurrent reclamation. Most of the affected stock ponds currently provide limited wetland values. Mitigation for stream channel disturbance is planned, and may be accelerated early in the project when the lignite is shallower and reclamation could proceed faster. Further descriptions of the extent and mitigation of jurisdictional waters of the U.S., including stream channels, ponds, wetlands, and related habitats, are presented in Section 3.2.5, Waters of the U.S. Including Wetlands.

Alcoa has proposed a draft Mitigation Plan (Appendix E) that addresses reclamation of wetlands, riparian woodland, and surface water features. The reclamation objective is to create features of similar nature and function to those existing prior to mining. The mitigation measures outlined in the plan include both onsite replacement of features removed within the area disturbed by mining plus creation or enhancement of additional features in an offsite protected area along Mine Creek and Middle Yegua Creek termed the Middle Yegua Mitigation Site. The goal of the offsite mitigation is to restore and enhance an intermittent stream floodplain to the highest quality riparian habitat within the Three Oaks Permit Area and to protect it in perpetuity.

Ephemeral and intermittent stream channels exhibiting ordinary high water marks (thus, meeting the primary criteria as waters of the U.S.) within the proposed mine disturbance area have been evaluated and characterized as low, medium, or high quality. Low-quality streams are defined as ephemeral streams that traverse open pastureland and have minimal hydrophytic vegetation or are highly eroded. Medium-quality streams are defined as ephemeral or intermittent streams that have a narrow, relatively undisturbed corridor of riparian woodland, native herbaceous, or hydrophytic vegetation and that are somewhat stable. Ephemeral or intermittent streams that have a broad, mature riparian corridor vegetated by desirable woodlands are characterized as high-quality.

Low-quality ephemeral streams would be mitigated at a minimum replacement ratio of 1:1 (based on the area of affected stream channel). Medium-quality streams would be mitigated at a minimum ratio of 1.5:1. High-quality streams and herbaceous wetlands would be replaced at a minimum ratio of 2:1. On-channel ponds (qualifying as waters of the U.S.) would be reclaimed at a minimum ratio of 1.5:1. Based on these mitigation ratios, the expected disturbance area and associated reclaimed area of various types of waters of the U.S. are summarized in **Table 3.2-9**.

Table 3.2-9
Surface Water Features Disturbed, Altered, or Displaced

Waters of the U.S.	Disturbance Area (linear feet)	Disturbance Area (acres)	Mitigation Ratio	Post-reclamation Area (linear feet)	Post-reclamation Area (acres)
Stream Low-Quality	51,511	6.7	1:1	51,511	6.7
Stream Medium-Quality	123,537	13.3	1.5:1	123,537	20.0
Stream High-Quality	23,370	3.6	2:1	23,370	7.2
Stream Subtotal		**23.6**			**33.9**
Ponds		38.5	1.5:1		57.8
Wetlands		5.3	2:1		10.6
Total Waters of the U.S.		**67.4**			**102.3**

Source: Alcoa 2002d.

As shown in the table, the total proposed mitigation acreage for direct impacts is 102.3 acres composed of 33.9 acres of stream channel, 57.8 acres of on-channel ponds, and 10.6 acres of herbaceous wetlands or suitable equivalent mitigation as described on Alcoa's draft Mitigation Plan (see Appendix E). A minimum of 23.6 acres of streams and 5.3 acres of herbaceous wetlands would be restored within the mine reclamation area (1:1 replacement of affected resources). Additional mitigation for stream and wetland disturbances would occur at the offsite Middle Yegua Mitigation Site. As an excess of the required acreage of ponds would be created within the mine reclamation area, no additional pond mitigation would be required offsite.

The remaining 10.3 acres of streams and 5.3 acres of herbaceous wetlands required to meet the approved mitigation ratios would be accomplished in the offsite Middle Yegua Mitigation Site by the enhancement of an existing riparian corridor and the creation of wetlands. Mitigation for temporal impacts also would occur in the Middle Yegua Mitigation Site. This proposed mitigation, at a ratio of 0.5:1, would include 11.8 acres for stream channels and 2.7 acres for wetlands. Thus, the total required mitigation in this site would be 22.1 acres for streams and 8.0 acres for wetlands. Because the offsite stream channel mitigation in the Middle Yegua Mitigation Site is proposed as enhancement in an existing stream corridor, the acreage would be doubled to 44.2 acres. Since the wetland mitigation would occur through creation of new wetlands rather than enhancement of existing areas, no doubling would be required. In summary, the proposed mitigation of affected waters of the U.S. would include restoration of at least 23.6 acres of stream channel, 5.3 acres of wetlands, and 57.8 acres of on-channel ponds within the reclaimed mine area plus creation of 8.0 acres of new wetland and 44.2 acres of stream channel/riparian enhancement in the Middle Yegua Mitigation Site.

The proposed surface water control system is described in Section 2.5, Proposed Action. With this system, approximately 30 acres of pond water surface would be present during operations in the mining area as a result of normal operating levels in sediment ponds SP-1 through SP-6. Additional water surfaces would be restored in phases via construction of the reclamation ponds (RPC and RPL ponds) during concurrent and final reclamation. Smaller ponds ultimately would be restored in a distributed manner within the mining area. In addition, two end lakes totaling approximately 722 acres would be created on the post-mining surface.

Typically, there would be a 20- to 30-month delay between the removal of a stock pond and reclamation of the area where it was located. Since disturbance and reclamation both would proceed in phases over the area to be mined, a temporal impact would occur as the pit and backfill progress. In addition, the geographic distribution of large numbers of scattered stock ponds and small depressions would change. Additional surface water acreage would be developed in the proposed end lakes. Once the end lakes are in place and filled, the total acreage of newly impounded surface water in the permit area would be approximately 895 acres.

The phased installation of diversion structures during operations would offset some of the potential impacts associated with the removal of waters of the U.S. and upland drainage features. The proposed post-mining topography and the position of many of the proposed reclamation ponds are shown in **Figure 2-14**, Post-mine Land Uses. Temporary impacts to drainageways (ephemeral and intermittent stream channels) would occur as the original system is removed and sequentially replaced by the post-mining configuration.

Effects from Watershed Modifications. The reach of Middle Yegua Creek in the vicinity of the proposed permit area has been tentatively classified by TNRCC as intermittent with perennial pools. All other tributaries within the proposed permit area have been classified by TNRCC as intermittent with no perennial pools. Baseline investigations indicate that ephemeral or intermittent conditions exist on the areas that would be disturbed. Proposed mining activities and construction of surface water control systems may affect both flow rates and runoff volumes of downstream waterways. These control systems are described in Section 2.5. Alcoa has conducted hydrologic and hydraulic modeling for selected streams in and adjacent to the permit area in order to compare baseline conditions to active mining conditions (Alcoa 2000 [Volume 5]). On lower Mine Creek, flow in the channel immediately downstream of sediment pond SP-1 would reach a simulated peak stage of 439.8 feet and a peak velocity of 3.1 feet per second when modeling the 10-year, 24-hour event under existing conditions. Under the condition of active mining, the simulated peak stage was reduced to 436.4 feet, and the peak velocity was reduced to 1.7 feet per second. In addition, the simulated peak runoff was reduced from approximately 8,000 cfs to approximately 4,000 cfs. The total simulated runoff volume on Lower Mine Creek was reduced from approximately 3,000 acre-feet under existing conditions to approximately 1,600 acre-feet under the active mining scenario (Alcoa 2000 [Volume 10]).

Similar analyses were conducted for Big Sandy Creek at U.S. Highway 290 (station LBS) and Middle Yegua Creek just downstream of the proposed permit area (station LMY) (**Figure 3.2-21**) (Alcoa 2001b [Volume 5]). When compared to baseline conditions modeled at these stations, the results indicate substantial decreases in peak flows for both creeks under active mining conditions over the life of the mine. Total runoff volumes modeled for the selected storms (10-year through 100-year, 24-hour events) are projected to increase slightly for Big Sandy Creek at station LBS, and negligible changes are predicted for Middle Yegua Creek at station LMY during the active mining phase.

Peak flows are projected to decrease during mining as a result of the proposed surface water control system for surface water resources, since the sediment ponds would reduce flooding and the erosion potential of the channels and banks. In addition, releases from pond storage would sustain flows for a somewhat greater length of time after a runoff event. The modeling results projected that these effects on peak runoff would be similar for the Mine Creek, Big Sandy Creek, and Middle Yegua Creek drainages during the active mining phase. The modeling has shown there would be a substantial reduction in runoff volume in Mine Creek but not in Big Sandy or Middle Yegua Creeks. These effects would be less for the larger basins, due to their relatively smaller areas of disturbance. No effects from mining disturbance would occur in the Brushy Creek drainage.

Following mine closure and final reclamation, drainage from approximately 9,800 acres would be routed through detention ponds and end lakes. Detention of runoff in these structures would result in fewer and smaller flows into the downstream drainages. The end lakes would be constructed with spillways designed to pass flows during larger runoff events (Harden 2002a). These features would allow discharge to the downstream channels when the lakes overflow their outlets. This condition would be most likely to occur when the lakes are filled to capacity and storms occur during the winter and spring, when evaporation is at a minimum and precipitation amounts are maximum. During smaller events and during other seasons of the year, runoff that would have provided minor flows in downstream channels likely would be captured in the end lakes and evaporated. This would reduce flows in the immediate downstream portions of ephemeral channels such as Chocolate Creek, Willow Creek, and the unnamed eastern tributary of Willow Creek. The actual amount of reduction would depend on the reclaimed surface characteristics. Based on the amount of watershed controlled by end lakes or permanent ponds, it is reasonable to expect a slight post-mining reduction in mean annual yield for these smaller headwater tributaries. Flow in these tributaries is usually small (less than 1 cfs) and is quickly lost to seepage and evapotranspiration. The flow typically ceases during dry periods, particularly in the late spring, summer, and fall.

Following mining and reclamation, the overall flows in Chocolate Creek, lower Willow Creek, and parts of Mine Creek would incorporate the rate and timing of discharges from the end lakes and permanent ponds (see **Figures 3.2-21** and **2-14**). Runoff from adjacent undisturbed watershed areas also would contribute to ephemeral flows in these channels, as under existing conditions. Preliminary modeling of end lake discharges has been conducted to improve the understanding of their surface water flow regime (Harden 2002b). Although the configuration of the end lakes is still in planning stages, the preliminary designs provide adequate modeling inputs and reasonable results. The end lakes would be provided with spillways, and discharges to these downstream channels would occur fairly frequently.

Because of their substantial size and depths, the end lakes would not be similar to any of the other surface water features in either the existing landscape or the reclamation area following mining. They also are expected to have greater effects on watershed dynamics than would the smaller ponds.

The design of the end lakes would focus on creating deep, elongated configurations with shallow slopes at the margins. Fluctuation of the end lake levels would occur as a result of evaporation and rainfall/runoff contributions. Based on preliminary design, it is anticipated that the levels typically would vary over a range of 2 to 4 feet. Construction of the sloping shorelines would need to accommodate this variation and provide an additional margin for habitat and safety at shallower lake levels. As a result, additional mitigation may be appropriate (see mitigation measure SW-1 in Section 3.2.4.4, Monitoring and Mitigation Measures).

The proposed end lakes were investigated with the RESOP model using approximately 26 years of representative historical hydrologic and meteologic data. The historical period used for model inputs incorporated average, drought, and wet hydrologic conditions (see **Figure 2-14**). Results of the preliminary RESOP modeling are shown in **Table 3.2-10**.

Table 3.2-10
End Lake Modeling Summary

End Lake	Number of Months per Year in which Discharges would Occur (Range)	Number of Months per Year in which Discharges would Occur (Average)	Discharge Volumes in Months when Flows Occur (Range in acre-feet)	Discharge Volume in Months when Flows Occur (Average in acre-feet)
South	0 to 4	1.2	0 to 1163	281
North	0 to 6	2.0	0 to 2048	927

Source: Harden 2002b.

The results indicate that the end lakes would discharge in a manner that approximates the occurrence of larger runoff events and to some degree lower prior evaporative losses. Discharges to the ephemeral channels therefore would approximate the rainfall-driven, sporadic flow conditions typical in these channels in their undisturbed state for larger precipitation events. For example, instantaneous baseline data in **Table C-9** (see Appendix C) can be used to examine general flow conditions for representative ephemeral tributaries in the vicinity. Although the data are for a shorter period than was used for the RESOP modeling, they indicate that for the 24 months of instantaneous baseline data presented, flows occurred in 5 months at Station UWC, in 5 months at Station LWC, and in 5 months at Station CC. Substantial periods of zero flow conditions also occurred at these stations. In addition, it generally appears from the results that channel-forming discharges also may occur with frequencies reasonably similar to undisturbed conditions. The stream channels most likely to be affected by flow regime changes from the end lakes are relatively small, short ephemeral reaches in headwater positions. The altered regimes would be most noticeable with respect to minor precipitation events from which the resultant runoff would be impounded in the end lakes. Within 1-mile of the end lakes, all drainage would be into larger, undisturbed ephemeral streams (Lower Mine Creek and Chocolate Creek) that carried the original flow regime. In turn, these ephemeral channels drain into Big Sandy Creek and Middle Yegua Creek, where flow conditions are dominated by larger undisturbed watershed areas. Minimal flow impacts are anticipated on these larger streams.

Changes to the ephemeral flow conditions and watershed yield immediately downstream of the proposed end lakes would constitute surface water resource impacts. Immediately downstream of the proposed end lakes, the anticipated flow changes could result in altered sediment deposition and scour patterns in the stream channels. As a result, monitoring and mitigation may be appropriate (see mitigation measure SW-2 in Section 3.2.4.4, Monitoring and Mitigation Measures). The degree and extent of such localized impacts would be alleviated by undisturbed downstream conditions that dominate the overall flow regime. In addition, restoration of riparian corridors and stream channels would take place during reclamation. No long-term effects on channel geometry are anticipated farther downstream, assuming that large flows still would occur frequently under periodic conditions of larger rainfall events and higher lake levels.

Mining disturbance would comprise comparatively smaller proportions of the watersheds at the Lower Big Sandy and Middle Yegua Creek monitoring stations (LBS and LMY, respectively, **Figure 3.2-21**). After mining and reclamation, the area upstream of Big Sandy Creek at baseline gaging station LBS would be modified by the end lakes controlling runoff from 6.4 square miles in the Chocolate Creek tributary drainage. This area represents approximately 16 percent of the baseline watershed at station LBS. For baseline gaging station LMY on Middle Yegua Creek, the area contributing under most runoff conditions would be modified by approximately 8.9 square miles in the upper Willow Creek tributary being controlled by the end lakes. This comprises approximately 16 percent of the baseline area at station LMY. Runoff from these areas would terminate in the end lakes or permanent ponds under drier conditions. When the lakes are full and large rainfall-runoff events occur, spillways at the lakes and permanent ponds would allow continuation of flow downstream. This most likely would happen during the winter and spring during larger precipitation events. Hydrologic modeling of severe storms for the downstream stations LBS and LMY indicates that under post-mining conditions there would be substantial decreases in peak flow rates; however, total runoff volumes would remain essentially unchanged for the 10-year through 100-year storm events. This is consistent with the revised drainage patterns and flow routing conditions. These modifications to peak flows for larger events would constitute an impact to water resources.

According to estimates of post-mining conditions, approximately 1,724 acre-feet per year are anticipated to be evaporated from the two end lakes (Alcoa 2001b [Volume 5]). Assuming this amount is evenly divided between the two lakes, approximately 862 acre-feet per year would be lost from the Big Sandy drainage (south end lake) and the same from the Middle Yegua drainage (north end lake). If regional average annual surface water yields (based on the USGS gages near McDade and Dime Box) are representative of the project area watersheds, this value represents approximately 12 percent of the mean annual yield for the Big Sandy watershed at baseline monitoring station LBS. Similarly, the lake evaporation would represent approximately 9 percent of the mean annual yield for the Middle Yegua watershed at baseline monitoring station LMY. (It is assumed that evapotranspiration and other factors affecting flows already are incorporated into historical gaging records.)

Flows from the remaining undisturbed portions of the Big Sandy watershed, from Mine Creek, and from the undisturbed portions of the Middle Yegua watershed would continue to pass downstream. No effects from mining or reclamation would occur in the Brushy Creek drainage. The main branches of Little Sandy and Big Sandy Creeks lie outside of the permit area and would not be directly disturbed. The intermittent nature of Big Sandy Creek would continue; however, low-to-average flow rates and their durations near the mine would be somewhat decreased by impacts on the Chocolate Creek tributary. At most, the average amount of these decreases at LBS near McDade may be on the order of the 12 percent represented by the evaporation losses. The actual overall reduction in yield is likely to be much less than this as the end lakes would discharge when conditions allow, and the estimated post-mining evaporation losses may have been lost to the flow system under pre-mining conditions as well. This impact would be most noticeable during droughts, when discharges likely would not occur from the end lakes. Since Chocolate Creek is ephemeral and only flows in response to sufficient rainfall, during droughts under existing conditions its contributions to Big Sandy Creek are extremely limited. Under such circumstances, the potential effects from end lakes during droughts would be comparatively minimal.

Flow changes may create little or minimal impacts to any perennial pools that occur along Big Sandy Creek near the mine. This conclusion is based on hydrologic investigations for a parallel situation on Middle Yegua Creek (Harden 2002c), as discussed in greater detail below. For comparative purposes, a perennial pool that was 0.25-mile-long, averaging 20 feet wide and 2 feet deep would hold a volume of approximately 1.2 acre-feet. Runoff volumes into Big Sandy Creek without the end lake contributions would be expected to be many times larger and would occur in concert with the typically variable rainfall conditions in the area. Runoff volumes with contributions routed through the end lakes would be larger still, as discussed below.

Big Sandy is joined by other tributaries immediately downstream of station LBS, and the effects of end lake control drainage on low-to-average flows would diminish with distance downstream toward the Colorado River. The overall drainage area of Big Sandy Creek is approximately 110 square miles at its confluence with the lower Colorado River. The area controlled by end lakes on the reclaimed mine would represent less than 6 percent of the overall Big Sandy watershed, and runoff from larger flow events likely would pass through the end lakes except in those instances when lake levels are low. Due to these conditions, and the fact that much of the Big Sandy flow is lost to seepage and evapotranspiration, negligible effects from watershed modifications are anticipated on the Colorado River.

A short reach of Middle Yegua Creek passes through the permit area; however, it would not be directly disturbed. Mine Creek would continue to be routed into Middle Yegua Creek through an existing culvert under a local road. The intermittent nature of Middle Yegua Creek would continue. Similarly to Big Sandy Creek, low-to-average flow rates and their durations would decrease on Middle Yegua Creek. The amount of these decreases at LMY may be on the order of the 9 percent represented by the potential evaporation losses from the north end lake as described above. The actual reduction in yield likely would be much less than this as the end lake would discharge when conditions allow, and the estimated post-mining evaporation losses may be lost to the flow system under pre-mining conditions as well. Such watershed yield reductions would be most noticeable during droughts. Since Willow Creek and upper Mine Creek are ephemeral and flow only in response to sufficient rainfall, during droughts under existing conditions their contributions to Middle Yegua Creek are extremely limited. Although impacts would occur as a result of the potential effects from end lakes during droughts, they would be comparatively minimal.

To investigate this further, hydrologic calculations were performed to generally estimate runoff volumes at station LMY for a range of hypothetical storm events and antecedent moisture conditions (condition in the watershed prior to rainfall) (Harden 2002c). Runoff curve numbers and watershed areas were input in accordance with previous modeling procedures for the mine permit application. The results, which are useful for comparative purposes, are shown in **Table 3.2-11**.

Table 3.2-11
Runoff Volume Comparisons at Station LMY
(acre-feet)

Rainfall Event (inches)	0.75	1.5	2.0	4.0
Conditions/Runoff Situation	**Runoff Volume (acre-feet)**			
Antecedent moisture condition 1 +0.6[1]				
Total runoff at LMY without contributions from north end lake	0.0	41.8	245.4	2214.2
Total runoff at LMY with contributions from north end lake	0.0	78.4	359.4	2891.9
Antecedent moisture condition approximately 2.5[1]				
Total runoff at LMY without contributions from north end lake	49.6	666.4	1324.0	4866.5
Total runoff at LMY with contributions from north end lake	78.7	880.9	1713.6	6129.4

[1]Antecedent moisture condition refers to the condition in the watershed prior to the rainfall, with lower values indicating drier conditions of the soil and surface. The value 1+0.6 is often used for hydrologic modeling in Texas. A value of 2.5 indicates that conditions in the watershed are comparatively wet when rainfall occurs.

Source: RWHA 2002c.

Rainfall does not always produce runoff if moisture conditions on the land are not conducive. It can be seen in the table that under drier antecedent conditions, a rainfall of 0.75 inch does not produce runoff at LMY, even though a large part (approximately 60 percent) of the watershed would remain undisturbed and uncontrolled. The differences with wetter antecedent conditions can be seen in the lower part of the table. Under either condition, the greater impermeable area contributed by the end lakes would increase the total runoff volume when they do contribute flows. However, as noted previously, the end lakes also would reduce peak flow rates due to routing effects.

Flow changes would create little or minimal effects on any perennial pools that occur along Middle Yegua Creek near the mine. If there is sufficient rainfall in the region to produce runoff at LMY, the total volume of any perennial pools that may occur in Middle Yegua Creek in the vicinity is likely to be much less than the runoff volumes shown in **Table 3.2-11**. Similar conditions would apply to Big Sandy Creek, as discussed previously.

Additional contributing watersheds join Middle Yegua Creek shortly downstream of station LMY, and the effects on flow from end lake control would diminish downstream of that point. At the Middle Yegua USGS gage near Dime Box, the drainage area is approximately 236 square miles. The subarea draining to the north end lake and to permanent ponds RPC-1 and SP-1 on the reclaimed site represents approximately 3.8 percent of that watershed. The area controlled by Somerville Lake is approximately 1,003 square miles, and the watersheds draining to reclaimed area impoundments represent approximately 0.9 percent of that area. No effects from mining disturbance or reclamation would occur on Brushy Creek. Negligible effects are anticipated to Somerville Lake and to the Brazos River downstream. Somerville Lake evaporation losses are estimated at approximately 19,000 acre-feet per year at normal pool extent, and approximately 205,000 acre-feet per year of water is released from the lake downstream to the Brazos River. Changes in watershed yields from the reclaimed mine area would represent a small fraction of these values.

Effects from Road and Bridge Improvements. Approximately 20 culverts would be placed under the proposed Three Oaks-to-Sandow haul road during its construction (Alcoa 2001b [Volume 6]). The SEDCAD computer model was used to determine the peak flows for each culvert, using the 10-year, 6-hour event. The culverts themselves were designed using the Texas Hydraulic System Culvert Design computer model. Each of the culvert structures would have a rip-rap lined channel section at the outlet to prevent channel erosion. Culverts having flow velocities greater than 9 feet per second would have grouted outlets followed by a rip-rap section downstream. Haul road ditches also were designed in accordance with standard practice, and are proposed to have a bottom width of 10 feet with sideslopes of 4 horizontal:1 vertical. Grass or rock lining would be utilized at appropriate locations in accordance with hydraulic modeling to minimize scouring.

A bridge crossing of Middle Yegua Creek also is proposed, and the hydraulics of the design have been analyzed. The proposed bridge crossing of Middle Yegua Creek is the only crossing that would potentially be subject to TNRCC regulatory review and approval. All other proposed crossings would consist of culverts on ephemeral stream channels. Review of floodplain maps issued by the Federal Emergency Management Agency (FEMA) indicate that the proposed Middle Yegua Creek crossing is the only proposed crossing that would cross through a Zone A 100-year floodplain (FEMA 1982). A Zone A determination is based on approximate methods rather than detailed hydraulic analysis. TNRCC has reviewed the design and determined that the bridge would not significantly control, regulate, or otherwise change the floodwaters of Middle Yegua Creek and, therefore, does not fall under TNRCC's jurisdiction (Alcoa 2001b [Volume 6]).

All stream crossings would be constructed in a manner to minimize impacts to streams. The proposed bridge and culverts would be sized to adequately carry the flow and minimize disturbances upstream or downstream from the proposed crossings. The proposed bridge over Middle Yegua Creek is the only crossing that would require substantial upstream or downstream channel modification. All non-rocked surfaces of the crossing would be promptly revegetated to minimize erosion and sedimentation. Silt fences and other BMPs would be utilized during and after construction to control erosion and promote revegetation.

As the construction of culverts and the proposed bridge may generate changes to the channel cross-sections and promote ongoing bed and bank changes (scour, bank caving, and sedimentation), potential impacts to stream channels may occur. The potential for such impacts may be reduced by the proposed control practices. However, additional mitigation of such impacts may be appropriate (see mitigation measure SW-3 in Section 3.2.4.4, Monitoring and Mitigation Measures).

Effects to Surface Water Resources from Water Level Changes. The majority of stream flow in the study area originates from precipitation events. However, small flows from groundwater contribution (baseflows) appear to exist for some of the stream segments, specifically for the intermittent streams, in the study area. These gaining reaches, along with known seep and spring locations, are associated with the outcrop areas of the Simsboro and Carrizo aquifers, as shown in **Figure 3.2-22**. Depressurization and dewatering pumping in the Simsboro and Calvert Bluff aquifers, respectively, is not projected to affect the Carrizo aquifer, as discussed in Section 3.2.3.2 under Impacts to Groundwater Levels. As a result, gaining reaches and spring and seep flows originating from the Carrizo aquifer outcrop would not be affected by the Proposed Action.

Gaining reaches of streams were determined through analysis of field data and measured groundwater levels. Field data were collected by RWHA (Alcoa 2000 [Volume 5]) between December 1999 and August 2000 for streams within the study area that had existing flow. Due to dry and low precipitation conditions, it was assumed that these flowing reaches were fed by groundwater. For the EIS analysis, the field data were extrapolated through data review of the depth to water measurements for wells completed in outcrop areas of the Simsboro and Carrizo aquifers. To provide a conservative approximation for this EIS analysis, additional gaining reaches have been assumed to exist within an approximately 1-mile radius of monitoring wells that indicated a depth to water of 10 feet or less. The actual length of gaining reaches could vary between this radius and a much smaller distance (e.g., 100 yards or less), depending on the geologic setting of the channel and evapotranspiration demands. Flow gains and losses in the area channels also are likely to vary substantially with seasons and with wet or dry climatic cycles.

Potentially gaining reaches in the study area include downstream reaches of Little Sandy Creek and Burlson Creek near the confluence with Big Sandy Creek; upstream and western tributaries to Big Sandy Creek, as well as reaches near Big Sandy Creek's confluence with the Colorado River; and upstream tributaries to Middle Yegua Creek. No gaining streams have been identified in association with the Calvert Bluff aquifer, due to the low permeability of the clay units and resulting confinement of available groundwater primarily to the sand lenses within the Calvert Bluff Formation, as described in Section 3.2.3.2 under Impacts to Groundwater Levels, Calvert Bluff Aquifer Dewatering.

Natural baseflows in the study area are commonly small (approximately 0.5 cfs or less seasonally for Simsboro outcrop baseflows), and during the summer months seepage into the channels is typically taken up by evapotranspiration over comparatively short reaches, particularly under drought conditions (Alcoa 2001b [Volume 5]). Review of data collected during the baseline surface water inventory suggests that recent baseflow contributions typically have been within that range on Little Sandy Creek (station LLS) immediately west of the permit area. In contrast, baseflows in the uppermost reaches of Big Sandy Creek (station UBS) are much smaller (approximately 0.02 to 0.1 cfs). This illustrates the wide variation in baseflow magnitudes across even a relatively small area.

Both stations LLS and UBS, were identified by RWHA (Alcoa 2001b [Volume 5]) as being within a part of the study area that exhibits baseflow contributions. In addition, these stations exhibited a more consistent occurrence of flow than other stations in the vicinity. Zero-flow conditions were common along Lower Mine Creek at station LMC, for example. This station has a watershed similar in size to that of Little Sandy Creek at station LLS, which had nearly continuous flow. As with Mine Creek, other creeks having negligible baseflow contribution include Chocolate Creek and Willow Creek. These results are indicated in **Figure 3.2-21**.

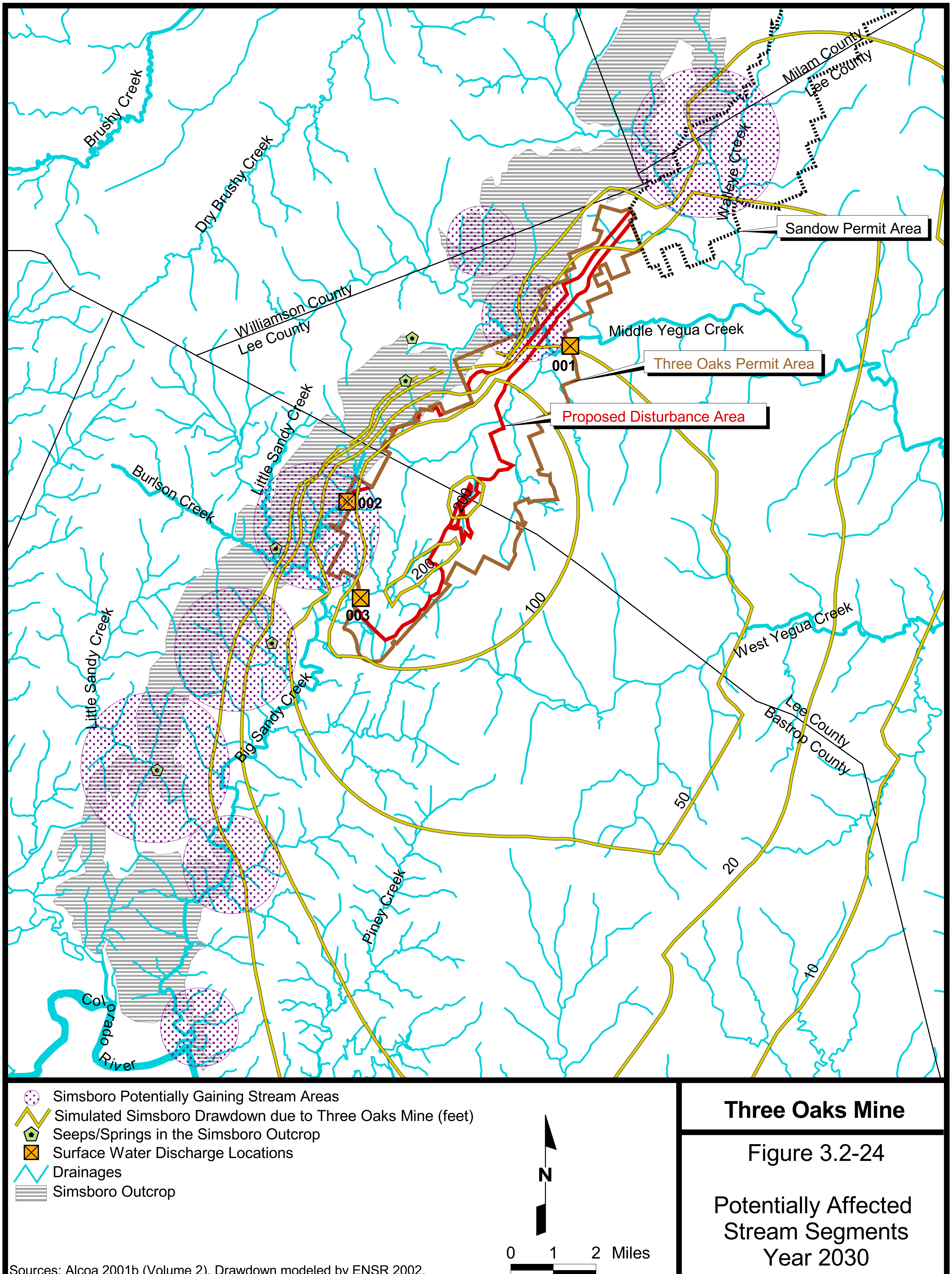
Flow losses, as indicated by decreases in average flow per square mile, occur along Big Sandy Creek between its confluence with Little Sandy Creek west of the permit area and the next downstream gage at station LBS. By a similar comparison, additional decreases occur between station LBS (USGS station 08159165, Big Sandy Creek near McDade) and the next downstream historical data point (USGS station 08159170, Big Sandy Creek near Elgin) (**Figure 3.2-1**). These data suggest that the occurrence of groundwater contributions from the Simsboro outcrop to surface flows are of limited extent and magnitude in the permit area vicinity, and that such contributions are lost to infiltration and evapotranspiration within relatively short distances.

As noted earlier in Section 3.2.4.1, Middle Yegua Creek within the permit area has been tentatively classified by TNRCC as intermittent with perennial pools. It is assumed from USGS gaging records that this classification applies to Middle Yegua Creek downstream to the study area boundary. All other streams in the permit area have been classified by the TNRCC as intermittent with no perennial pools; however, field observations indicate that most channel reaches are ephemeral. Based on USGS gaging records, Big Sandy Creek and East Yegua Creek from the permit area boundary to the study area boundary are intermittent with perennial pools.

The approximate location of gaining reaches of streams associated with the outcrop of the Simsboro Formation in relation to the modeled drawdown contours within the Simsboro aquifer are shown in **Figure 3.2-24**, based on the assumptions described above. Drawdown within the Simsboro aquifer as a result of depressurization activities may result in decreased flows in the gaining reaches of streams associated with the Simsboro outcrop area, depending on the stream's location within the drawdown cone. In those areas where the groundwater drawdown within the outcrop is projected to be 10 feet or less, it is not anticipated that gaining reaches would experience a measurable decline in groundwater baseflow contribution. Gaining stream segments within the 10- to 20-foot drawdown area may experience a decline in groundwater baseflow contribution, and it is anticipated that the gaining reaches within the 20-foot or greater drawdown area would experience a measurable decline in groundwater baseflow contribution (see **Figure 3.2-24**). The intermittent nature of the major streams in the study area would not be affected by drawdown-induced baseflow reductions; however, the duration of seasonal stream flows and associated temporary or perennial pools that may exist in the major channels may be decreased, depending on the location in relation to the drawdown contours.

The level of impact to gaining reaches of streams in the study area from drawdown in the Simsboro aquifer would vary based on the percentage of total flow currently provided by groundwater baseflow. While data do not exist to accurately determine this contribution, available data demonstrate that total flow in all but one gaining reach associated with the Simsboro outcrop was less than 0.2 cubic feet per second (cfs) at the time of the RWHA. low-flow survey (Alcoa 2000 [Volume 5]). Data from one sample location on Little Sandy Creek showed natural flows of greater than 0.2 cfs, which indicates a larger baseflow contribution during the low-flow measurement program. One sample location on Middle Yegua Creek and one sample location on a tributary to Middle Yegua Creek also showed flows greater than 0.2 cfs; however, it is likely that these flows were due to discharges from the Sandow Mine or the City of Elgin wastewater plant rather than natural baseflow contributions (Alcoa 2001b [Volume 2]). **Table 3.2-12** provides the mean daily flow rate for Middle Yegua and Big Sandy Creeks. In general, the smaller the mean flow rate for a given stream, the greater potential impact baseflow reductions may have on stream flow. However, comparisons must be made cautiously to ensure that the gaged areas and periods of record are the same. Similar data are not available for other potentially gaining reaches identified in the study area.

Groundwater recharge and the associated volume of groundwater contribution to a stream varies seasonally and annually due to precipitation and other meteorological conditions. In addition, overland flow, through flow (routed from upstream), and direct precipitation contributions to a stream also varies based on the



Three Oaks Mine

Figure 3.2-24

Potentially Affected Stream Segments Year 2030

6/19/02

Table 3.2-12
Mean Daily Stream Flow[1]

Stream Name and Gaging Location	USGS Gaging Station Number	Period of Record	Mean Daily Flow Rate (cfs)
Middle Yegua Creek near Dime Box	08109700	8/62 - 9/00	56.0
Big Sandy Creek near McDade	08159165	8/79 - 9/85	8.8

[1]No data exist for Little Sandy or Burlson Creeks. The flow for these creeks can be assumed to be less than for Big Sandy Creek. Data do not exist for West Yegua Creek.

rainfall during a given time period. Due to the fact that most streamflows in the area rely on precipitation, baseflow reductions in the study area typically would have the greatest impact on surface water quantity in gaining reaches during times of low precipitation.

The potentially gaining reaches most likely to be affected by groundwater withdrawal from the Simsboro aquifer include the upstream tributaries to Big Sandy Creek, Middle Yegua Creek, and Walleye Creek. On the upper Big Sandy tributaries, a modeled drawdown of 50 to 100 feet in the aquifer would have the greatest impact on groundwater baseflows. Other channel sections on Little Sandy Creek and Big Sandy Creek, specifically those reaches located within the 20- and 50-foot drawdown contours, may have measurable baseflow declines (see **Figure 3.2-24**). On Big Sandy Creek below TPDES Outfall 002, these effects may be outweighed during mining by releases at the outfall. A short gaining reach upstream of the outfall likely would be affected by baseflow losses during mining, as would a short section of Little Sandy Creek near its confluence with Big Sandy. After mining (and associated TPDES discharges) ceases, the channel sections below the former outfalls likely would experience measurable declines in groundwater baseflow contributions. The actual decreases would be small (probably less than 0.25 cfs) but are difficult to quantify since baseflows vary seasonally, and the stream flow in this vicinity is typically non-existent in late summer and early fall. Downstream reaches also may experience slightly smaller flows as less water is routed in from upstream. As shown in **Table 3.2-12**, the recorded mean daily flow rate in Big Sandy Creek at the gage near McDade is relatively low (8.8 cfs), even when measured downstream of the permit area. Although seasonal variation and year-to-year changes dramatically depart from this mean value, these smaller flow rates are probably more sensitive to potential baseflow reductions. Additional monitoring and mitigation measures may be appropriate (see mitigation measure SW-4 in Section 3.2.4.4, Monitoring and Mitigation Measures).

The effects of baseflow reduction would be most noticeable upstream of Station LBS (near McDade). Below LBS, USGS stream gage data indicate that the reach is generally losing flow to the Simsboro outcrop in its pre-mining condition. During the life of the mine, baseflow reductions largely would be outweighed by additional contributions of dewatering and depressurization discharges at TPDES Outfalls 002 and 003, as described below under Effects of Discharges to Streams. As these flow augmentations cease at the end of mining, recharge to the Simsboro aquifer would begin. The net effect would be that some baseflow reduction would occur; however, it would be after the cessation of mining and would last until near-surface outcrop zones are recharged. The magnitude of these impacts on streamflow would vary substantially from year to year, given the wide variation in precipitation and associated near-surface recharge already typical of the region. These impacts would decrease as the aquifer recharges and may not be noticeable in wetter than average years. However, overall, the effects from water table drawdown would have an adverse impact as a result of decreased flows on Big Sandy Creek near the permit area after mining.

Also it is likely that a portion of Middle Yegua Creek in and just upstream of the permit area would experience a measurable decline in baseflow contribution during and after mining (see **Figure 3.2-24**). Drawdown of 20 to 50 feet is projected in the Simsboro aquifer along this potentially gaining reach. The potential flow modifications would be similar to that described for Big Sandy Creek. These impacts potentially would occur upstream of TPDES Outfall 001 and likely would affect the short reach both during and after mining. Impacts to the channel section farther downstream would be alleviated during mining by discharges at the outfall. After mining and reclamation, both baseflow decreases and reductions in overall watershed yield would act together to reduce flows in the reach below Station LMY. In most seasons, these impacts largely would be alleviated by contributions from incoming tributaries along Middle Yegua between LMY and the Walleye Creek confluence. However, there also may be some decline in groundwater baseflow contributions from Sandy Creek, Grass Creek, and Walleye Creek both during and after mining. Again, the actual flow decreases are likely to be small and may be inconsequential in these channels since they normally go dry in most years under natural conditions. However, as a result of the potential effects to these smaller tributaries during and after mining, and the effects of decreasing low flows on Middle Yegua Creek near the permit area after mining, adverse impacts on surface water resources are likely to occur.

Springs and seeps that are associated with the Simsboro outcrop and that occur within the modeled drawdown area may experience a direct adverse impact to water quantity, depending on their location within the drawdown area and the seasonal and annual weather conditions. Springs known to occur in the study area are shown in **Figure 3.2-24**, in combination with the projected LOM drawdown (in feet) in the Simsboro aquifer outcrop. Springs that occur within the drawdown area of 20 feet or more likely would be affected by the proposed depressurization pumping. Only one spring, as shown in the center left portion of **Figure 3.2-24**, likely would be affected. Springs that occur in the 10- to 20-foot drawdown zones may be affected by depressurization pumping. By reasonably interpolating drawdown contours, one additional spring may be affected, as shown in **Figure 3.2-24** in the north-central part of the Simsboro outcrop. Springs that occur in areas estimated to undergo less than 10 feet of drawdown are not anticipated to be affected by depressurization pumping. In **Figure 3.2-24**, five additional springs are shown on or near the Simsboro outcrop that fit into this latter category. The Simsboro outcrop at or near these springs is anticipated to undergo approximately 5 feet (or less) of drawdown during the life of the mine.

It should be noted that springs are associated with surface exposures (outcrops) of the water-bearing formations or aquifers that supply flow to them. A number of other springs are shown in **Figure 3.2-24** that would not be affected by depressurization activities in the Simsboro aquifer. These are shown to the northeast of McDade, in areas largely associated with the Carrizo outcrop. No springs are known to occur in the study area in association with the Calvert Bluff Formation outcrop.

Effects of Discharges to Streams. Estimates of total dewatering and depressurization discharges for the Three Oaks Mine are shown in **Table 3.2-13**. Industrial water demands (at the power plant and smelter) would continue to be met by the well field at the Sandow Mine. Alcoa currently proposes to use collected storm water runoff from disturbed areas and dewatering water from the Three Oaks Mine for the

Table 3.2-13
Estimated Discharges from Combined Dewatering and Depressurization Well Pumping[1]

Mine Year	Approximate Pumping Discharge (acre-feet per year)	Approximate Pumping Discharge (cubic feet/second)
1	2,800	3.9
2	2,700	3.7
3	3,500	4.8
4	5,500	7.6
5	5,300	7.3
6 - 10	5,700	7.9
11 - 15	7,400	10.2
16 - 20	9,800	13.5
21 - 25	10,600	14.6

[1]Assumes that water for dust control and other industrial uses is included and no other pumping occurs for other purposes.

Source: Hodges 2002a.

approximately 950 to 1,300 acre-feet per year of projected water usage at the mine. Excess dewatering well water and disturbance area storm water runoff volumes would be discharged through the sediment pond system. Depressurization water would be discharged from the site without routing through the sediment ponds. Also it should be noted that runoff collected in the pits would be routed through the mine storm water control system (Alcoa 2001b [Volume 5]).

Flows in Big Sandy, Chocolate, Lower Mine, and Middle Yegua Creeks would be augmented by releases from the mine water control ponds and TPDES outfalls during the life of the mine. During this 25-year operational phase, the augmentation would provide flow on a more continuous basis than under baseline conditions. These increased flows would occur for a distance of approximately 4 to 6 miles downstream of the discharge locations. This augmentation would end during the closure and reclamation phase, and the streamflow regimes from rainfall-runoff events then would be as described previously under Effects from Watershed Modifications.

Three TDPES outfalls (discharge points) are proposed, and all excess water would be discharged at these outfalls to stream channels. These outfalls are shown in **Figure 3.2-24** as location 001 on Middle Yegua Creek, and locations 002 and 003 on Big Sandy Creek. With average annual runoff included in the discharge estimates, the range of releases at Outfall 001 is estimated to be 13 to 18.5 cfs (9,400 to 13,400-acre-feet per year). Including average annual runoff, the range of releases at Outfall 002 is estimated to be 0 to 1.0 cfs (0 to 725 acre-feet per year), and at Outfall 003 it is estimated to be 3.3 to 8.7 cfs (2,400 to 6,300-acre-feet per year). It should be noted that these estimates are based on average conditions; the actual rates would vary depending on pumping rates, mine water use, mitigation demands, and the occurrence of large storm events. Typical discharge rates likely would be somewhat smaller than the ranges presented but may increase substantially for periods of days or weeks following storms. During these periods, it is likely that flows in the downstream channels also would increase as a result of more widespread watershed conditions, and effects from mine discharges would be minor.

The flow rates from the discharges to the Big Sandy and Middle Yegua watersheds would not affect channel or bank morphology, nor would they increase the flooding hazard. It is assumed that outlet structures would be designed to ensure stream stability through the use of designs similar to those used for sediment pond outlets and diversion channels. Channel and bank morphology typically are determined by bankfull flows, which are often estimated as the peak flow having a recurrence interval of 2.33 years. These flows (on the order of 50, 500, and 3,500 cfs at proposed outfalls 002, 003, and 001, respectively) are far greater than the potential pumping discharges. Less frequent flood events (e.g., a 10-year event) are larger still, and the magnitude of channel-forming flows increases farther downstream on Big Sandy and Middle Yegua Creeks. Low-flow channels are not anticipated to be substantially modified due to the small discharge flow rates and frequently cohesive nature of the sediments. There may be slight, isolated downcutting in the low-flow portion of the main channels; however, this is not expected to contribute substantially to additional erosion and sedimentation. As stated in Section 3.2.4.1, suspended sediment concentrations in the streams vary greatly, but are substantially higher during higher flows. During the active mining phase, continuous streamflow would occur over a longer reach of channel, and water may stand temporarily in isolated pools for a longer period than prior to mine-related discharges. However, the additional flow from groundwater discharge is likely to seep into the channel bed or be taken up by evapotranspiration within several miles of the discharge point. Alcoa would mitigate impacts to low water crossings if the normal ability to cross the channel is impaired by flow increases (Alcoa 2001b [Volume 5]).

Reductions in surface water flows from water table drawdown, as previously described, generally would be outweighed near the permit area by the pumping and storm water discharges during the life of the mine. These discharge rates and the locations of discharge would vary over time. It is possible that on some occasions, effects from aquifer water level changes may reduce baseflows over a short period when discharges are not occurring (or are severely limited) at one or more of the outfalls during the life of the mine. During such periods, the streamflows below the outfalls temporarily would be reduced, as previously described. This would create a temporary impact on surface water resources. As a result, additional mitigation may be appropriate (see mitigation measure SW-4 in Section 3.2.4.4, Monitoring and Mitigation Measures).

Surface Water Quality Impacts

Surface water quality issues associated with lignite mining generally involve the potential for increased sediment transport, nutrient and pesticide loading, and acid or toxic drainage resulting in increases in iron, manganese, or TDS. Sediment, metals, and metalloids can be treated through the use of flocculant or other chemical methods to reduce their concentration. Total dissolved solids may increase in mine area discharges, depending on the nature and timing of groundwater contributions to the sediment pond/storm water management system. All discharges during the life of the mine would be treated as necessary to meet TPDES and RRC water quality standards.

No impacts to surface water quality are anticipated from dissolved or total metals, metalloids, or non-metals content in runoff or groundwater. For example, selenium levels are below laboratory detection limits in the vast majority of baseline groundwater samples (Alcoa 2000 [Volume 4]). This also is true for other constituents, as shown in baseline sampling from the Three Oaks vicinity. Water quality data from active mining conditions at the Sandow Mine also show that selenium and other constituents tested below detection limits in the vast majority of samples (Hodges 2002b). A review of overburden and interburden data shows that in a small number of cases, selenium levels exceeding the topsoil suitability guidelines occur (see Section 3.3.2.1). However, as discussed in that section, large volumes of suitable reclamation materials are available without such limitations, and these materials would be used in reclamation. In combination with Alcoa's proposed selective handling program and TPDES provisions, no sources of selenium that could affect surface water quality are expected to occur.

Surface water runoff and other discharges from dewatering and depressurization proposed at the Three Oaks Mine would be discharged to local drainages. The sediment ponds are designed to detain (as opposed to retain) the design storm events. Spillway configurations are designed to safely pass the projected peak flow, and the design elevation of the spillway base is several feet below the maximum predicted depth in the pond to provide for discharge while preventing lateral erosion of the embankment. Subsequent releases of treated runoff are proposed via underflow drains, which would normally be in the closed position except during these releases. Adequate water treatment technologies (including retention, settling, and the use of flocculants) have been demonstrated at the Sandow Mine, and these would be implemented as part of the Proposed Action based on the requirement for agency review and approval of the surface water management system. No drinking water supplies based on surface water resources are known to occur in downstream areas near the proposed project area.

Appropriate pond and ditch maintenance performed during mining and early reclamation, in addition to successful reclamation and revegetation practices, should ensure adequate functioning of the proposed erosion and sedimentation controls designed to protect water quality. Peak flows and event runoff volumes were derived using standard procedures, local data, and inputs as recommended in Texas engineering literature and RRC regulations. Sediment volumes were derived by RUSLE inputs for sheet and rill erosion, with additional gully erosion estimates. RUSLE erosion rates were estimated using a conservative soil erodibility factor, and were calculated in a manner that reflects the advance of mining and reclamation. Pond sizing was designed to accommodate a regional sediment delivery ratio (0.43, as developed by NRCS studies) and a 3-year volume of sediment accumulation, in accordance with minimum volumes required by RRC assuming maintenance activities during mining and reclamation. The other erosion and sedimentation factors used in calculations appear to be reasonable or would be compensated for by the greater soil erodibility factor.

The adequacy of the sediment control features is further suggested by projection of the annual sediment accumulation rates for the Yegua Creek watershed as documented for Somerville Lake. It should be noted that Somerville Lake is located farther downstream in the watershed than the permit area. As a result, the watershed likely stores more sediment in lower sideslope positions, floodplain terraces, and stream channels than would be the case at the higher-positioned Three Oaks Mine. In addition, only a very small proportion of the Somerville Lake watershed is disturbed to the extent proposed for the Three Oaks Mine. However, even if five times the regional sediment yield were assumed for the mine area to account for disturbance and sediment delivery, more than sufficient volume for sediment accumulations has been accounted for in the sediment control pond designs.

Alcoa would contract with qualified individuals or companies to apply fertilizers and pesticides on reclaimed areas, as needed, to ensure successful reclamation. These contractors would operate in accordance with manufacturer recommendations and appropriate agency regulations regarding application rates and handling of materials. Use of fertilizers and pesticides on the reclaimed areas in accordance with recommended application rates and procedures is not anticipated to constitute a risk to water quality in local streams or groundwater, based on recent water quality monitoring data from locations directly downstream of the Sandow Mine (Hodges 2002b). However, nutrient-rich runoff from the reclaimed areas could result in periodic increases in nutrient levels in nearby sediment ponds and diversions. These runoff episodes could produce corresponding increases in algal species abundance in these waters.

To investigate this further, Alcoa has compiled water quality data from the Sandow Mine. Data represented historical sampling from locations both upstream and downstream of the mine. Nutrient levels, particularly those constituents involving nitrogen, were minimal in the downstream samples and were not elevated beyond those in the upstream samples (Hodges 2002b). Further, during Alcoa's reclamation program at the Three Oaks Mine, fertilizers would not be applied at the frequency or intensity that they would be for agricultural crop production. As a result, water quality impacts from nutrient-enriched runoff are expected to be negligible.

Water from pit dewatering and surface runoff from disturbed areas would be used for dust control (Alcoa 2001b [Volume 5]). Remaining water would be diluted with surface water runoff during higher flow events prior to release. Depressurization water from the Simsboro aquifer also would be used, as needed, to dilute water generated by pit dewatering prior to release at the TPDES outfalls. An analysis of the effects of discharging pit water through the surface water control system was conducted by RWHA. This analysis indicates that the actual surface water quality downstream of the permit area likely would be within the range of that measured in area creeks during the baseline inventory (Alcoa 2001b [Volume 5]). If the pit dewatering volume is predominantly used for dust control as proposed, only minor adverse impacts to downstream water quality would result. Protection of surface water quality would be further ensured by required TPDES and RRC monitoring programs downstream of the mine.

Selective handling of overburden and interburden would prevent acid or toxic drainage from the proposed project. Materials capable of generating acid or toxic drainage would be buried within the pit. As a result, they would not likely contribute to adverse surface water quality impacts. With the exception of the two end lakes and the RCP-1/SP-1 drainage, the entire recontoured surface would be well above the pre-mining water table in the Calvert Bluff Formation (Alcoa 2000 [Volume 4], 2001b [Volume 5]). In the post-mining topographic setting, the SP-1/RPC-1 drainage into Mine Creek would be configured to provide for surface water features and wildlife habitat (see **Figures 2-9** and **2-14**). Reclaimed land surface elevations in the drainageway would range from approximately 445 to 500 feet NGVD (Alcoa 2001b [Volume 5]). Pre-mining water levels in the Calvert Bluff Formation along the existing drainage range from approximately 448 to 478 feet NGVD (Alcoa 2000 [Volume 4]). After mining and reclamation, the water level in the Calvert Bluff materials gradually would recover, as described under Impacts to Groundwater Levels in Section 3.2.3.2. Assuming that the recovered water level generally would mimic the pre-mining conditions, the possibility exists that isolated groundwater seeps or small springs may occur at lower elevations in the reclaimed SP-1/RPC-1 drainageway. Post-mining surface flows and water quality in the Mine Creek drainage would be dominated by surface runoff from the reclaimed area, flows from the two ponds, and surface runoff from undisturbed areas farther downstream along the creek.

Overburden/interburden analyses indicate that some unsuitable materials exist in the SP-1/RPC-1 vicinity, as identified in boreholes K4921A and K5314A (Alcoa 2000 [Volume 4], 2001b [Volume 5]). Substantial volumes of suitable materials for reclamation also exist in the vicinity. Given the prior identification of these materials and the deep burial of acid-generating or toxic materials as a result of the proposed selective handling program, any seepage that does occur would not have come into contact with acid-generating or toxic materials. High carbonate content in the mixed spoil and demineralization from cation-exchange with clays in the mine spoil are anticipated to bring any water seeping from reclaimed Calvert Bluff sources to within the range of undisturbed background conditions in the region. This expectation is further supported by historical data from sampling ponds on Calvert Bluff spoils at the Sandow Mine. These data indicate that the pH in the Sandow ponds ranged from approximately 5.9 to 8.3 standard units, with a median value of approximately 7.4 standard units. TDS in the ponds ranged from 86 to 892 mg/l, with an average value of approximately 400 mg/l (Hodges 2002b). It is anticipated that post-mining water quality in the SP-1/RPC-1 drainage would meet applicable standards and be suitable for proposed post-mining land uses.

Additional potential erosion and sedimentation impacts may result from construction of haul road crossings at streams; Alcoa proposes to mitigate the potential impacts with a storm water protection plan developed for the construction of the bridge over Middle Yegua Creek (Alcoa 2000 [Volume 14]). Additional culvert and channel stabilization installations are included in the Proposed Action for other sections of the Three Oaks-to-Sandow haul road corridor. Haul road construction is anticipated to have minor adverse impacts on drainage; however, greater impacts may occur as a result of increased erosion and sedimentation, depending on potential changes to channel cross-sections. As a result, additional mitigation may be appropriate (see mitigation measure SW-3 in Section 3.2.4.4, Monitoring and Mitigation Measures).

As discussed in Section 3.2.3.2, the Proposed Action would not affect groundwater quality in the Simsboro aquifer, which provides baseflow to some of the creeks in the area. In addition, most of the surface water flow in the study area channels and perennial pools originates from precipitation events. As a result, neither the quality of the baseflow nor the decreases in baseflow would substantially affect water quality in the gaining reaches of streams associated with the Simsboro outcrop. In addition, discharges of groundwater to streams would be required to meet applicable surface water quality standards as required by TNRCC regulations. No adverse surface water quality impacts are anticipated from groundwater discharge or drawdown.

The primary determining factor for surface water quality in the region is rainfall runoff. During the mining phase, surface water quality would reflect the effectiveness of the surface water control system and discharges from groundwater pumping. Following reclamation, surface water quality largely would reflect rainfall runoff from the reclaimed areas and routing through the end lakes. The occurrence of isolated baseflows in stream channels from groundwater contribution within the 20-foot drawdown contour of the Simsboro aquifer outcrop would be rare or nonexistent during and for several decades after the completion of mining until the aquifer recovers.

Water quality data from field sampling indicate that the groundwater discharge temperature would be similar to surface water temperatures in the vicinity. It is assumed that both temperature and dissolved oxygen parameters would meet state water quality standards at the point of discharge or within a short mixing zone downstream as allowed by regulations (30 TAC Part 1, Chapter 307, Rule 307.8).

Based on the Carrizo aquifer's hydraulic separation from the Calvert Bluff and Simsboro aquifers, as discussed under Groundwater Quantity Impacts in Section 3.2.3.2, the projected drawdown in the Calvert Bluff and Simsboro aquifers would not affect groundwater levels or groundwater quality in the Carrizo aquifer. As a result, there would be no impact to water quality in the gaining reaches of West Yegua Creek and its tributaries, or to the quality of springs and seeps within the Carrizo outcrop area, as a result of the Proposed Action.

Effects on Surface Water Rights

No permitted surface water users are known to exist within the permit area or immediately downstream (Alcoa 2000 [Volume 5]). There may be unpermitted riparian water uses (primarily livestock watering) that occur periodically along these affected stream reaches. However, the normal flow regimes exhibit periods of dry or poorly sustained flow conditions, and Alcoa is required by regulations to address water supply and water rights impacts (TAC 2000d).

A plan for the protection of water users is included in the RRC permit application. Potential effects on surface water rights could occur as a result of changes in stream channels and watershed yield, discharges to streams, groundwater drawdown, or effects during construction and mining from the surface water control system, as discussed in other sections. The proposed activities have the potential to affect both riparian rights and other appropriated rights. However, the potential for this would be minimized or eliminated by the lack of surface water users near the project area and the requirement by RRC for effects on water supplies to be mitigated. Title 16 TAC Part 1 Chapter 12(G)(5) Rule 12.130 states that if surface mining activities may result in contamination, diminution, or interruption of an underground or surface source of water within the proposed permit area or adjacent areas which is used for domestic, agricultural, industrial, or other legitimate use, "then the application shall identify alternative sources of water supply that could be developed to replace the existing water sources, including the suitability of alternative sources for existing pre-mine and approved post-mine land uses." It is assumed that Alcoa would coordinate, as necessary, with RRC and TNRCC to appropriately comply with this regulation. Therefore, impacts to surface water rights near the mine would be negligible.

Farther downstream, rights to surface water and surface water conveyances are used by individuals and civil entities such as housing developments, municipalities, and irrigation districts. These are identified in Appendix C, **Tables C-15** and **C-16**, and are largely centered in the vicinity of Somerville Lake and downstream areas. Surface water effects from the proposed project are not anticipated to reach these downstream locations, primarily due to their distance from the mine, intervening watershed factors, and the generally limited magnitude of potential surface water impacts. Surface water flow rates, timing, and water quality are affected below the project area by additional stream tributaries, aquifer characteristics, evapotranspiration, channel seepage losses, variations in rainfall, and man-made storage, withdrawals and contributions. Variations in such factors are likely to have far more effect on the availability of water at these downstream locations than would the potential impacts from the proposed project. Minimal or negligible mine-related impacts to these more downstream water uses are expected.

No Action Alternative

Under the No Action Alternative, the Three Oaks Mine would not be developed. As a result, impacts to surface water quantity and quality resulting from the proposed Three Oaks Mine as described above would not occur. Annual and seasonal changes in water level, flow, and water quality characteristics would continue as they have in the past. There also would be potential changes associated with municipal water use.

3.2.4.3 Cumulative Surface Water Impacts

Three Oaks without SAWS

Cumulative impacts to surface water resources would result from previous and ongoing disturbance, the cessation of discharges, and final reclamation at the Sandow Mine; construction, operation, and initiation of discharge at the Three Oaks Mine; and surface water effects associated with cumulative groundwater drawdown in the Simsboro and Calvert Bluff aquifers. These potential impacts largely would be related to the magnitude and duration of surface water flow. Cumulative surface water quality impacts would be the same as those described under direct impacts for the Three Oaks Mine. No effects from Lake Bastrop or Alcoa Lake are anticipated, and no impacts to these surface water bodies would occur.

Removal of Surface Water Features. The historical distribution of water features at the Sandow Mine is estimated by Alcoa to have included approximately 60.6 acres of wetlands and approximately 117.8 acres of other waters of the U.S., the majority of which have been removed during mining. The remaining additional disturbance of surface water features at the Sandow Mine through 2003 is shown in **Table 3.2-14**. This additional disturbance in combination with the proposed disturbance at the Three Oaks Mine, would result in approximately 154 acres of new disturbance to surface water features. Potential impacts from these activities would be mitigated by Alcoa as required by the existing Section 404 permit for the Sandow Mine and as required for the pending Section 404 permit that may be issued for the Three Oaks Mine.

Table 3.2-14
Cumulative New Disturbance to Surface Water Features at the Sandow and Three Oaks Mines

Type	Additional Proposed Disturbance Acreage at Sandow	Proposed Disturbance Acreage at Three Oaks	Total Acreage Affected
Forested wetlands	18.5	0.0	18.5
Non-forested and undifferentiated wetlands	2.2	5.3	7.5
Ponds	25.1	69.9[1]	95.0
Streams	9.4	23.6	33.0
Total	**55.2**	**98.8**	**154.0**

[1]Includes 38.5 acres of on-channel ponds and 31.4 acres of off-channel ponds.

Source: Hodges 2001; Alcoa 2002a.

Effects from Watershed Modifications. Sandow Mine reclamation has involved and will involve recontouring, drainage restoration, and revegetation. Existing or future surface water and sediment controls will remain in effect during much of the period required for these activities. As landscape restoration proceeds, the controls implemented during the operational phases will be converted to their final reclaimed configurations. Reclamation and revegetation will mitigate potential impacts from surface drainage, erosion, and sedimentation on the mine site and in its vicinity.

A decrease in sediment yield from the Sandow Mine area is anticipated to occur for a number of years from permanent sediment controls and revegetation (Alcoa 1999). These factors, when combined with reduced flood peaks (discussed below), may result in minor streambed shifts for short reaches of Walleye and East Yegua Creeks. These impacts are not expected to be substantial, since the total sediment load in these higher tributaries is dominated by fine-textured suspended clays and silts that normally wash through with the flow. In addition, both channels represent smaller drainage areas that are joined downstream of the Sandow Mine area by additional streams (e.g., Ham Branch and Reece Branch on East Yegua, and a number of branches along Walleye Creek). The additional contributions of larger flows from undisturbed watershed areas would reduce the potential for more widespread channel effects from activities at the mine. Over the long term, additional watershed adjustments would occur on the reclaimed area and nearby. Eventually the overall flow and sediment yield conditions are expected to approximate pre-mining conditions.

The reclamation program at Sandow is anticipated to create approximately 38 post-mining impoundments and end lakes, with a surface area of approximately 772 acres. Most of these features would be 10 acres or larger in size, and several of them would be 50 to 100 acres in size (Alcoa 1999). These features, in combination with permanent drainageway reclamation, would create additional surface water features. Following final reclamation at the Three Oaks Mine, a total of approximately 1,667 acres of ponded water features eventually would be distributed on the reclaimed areas of the two mines. Additional acreages of drainageway corridors also would be restored or enhanced as outlined in Alcoa's Mitigation Plan (see Appendix E).

The creation of end lakes would result in residual impacts in the form of additional surface water resources, altered sediment dynamics, and somewhat reduced watershed yields. Flows routed through the end lakes would contribute to downstream channel flows during periods of larger storm events and lower evaporation withdrawals. On average, this is likely to occur at least once a year. However, during droughts the end lakes would not discharge. This would generate an adverse impact, the effects of which may be somewhat reduced, since the nearby streams are ephemeral and likely would not have flowed during similar conditions in their pre-mining state. However, these ephemeral tributaries would flow, even in drought conditions, during precipitation events.

Based on hydrologic modeling, Sandow Mine reclamation is anticipated to reduce peak flows approximately 30 to 40 percent on East Yegua Creek upstream of U.S. Highway 77. A 10 to 14 percent peak flow reduction also is predicted for Cross Creek near the mine. However, total runoff volumes are expected to generally remain unchanged from baseline conditions (Alcoa 1999). These findings would apply to large runoff events that would occur at intervals of a year or more. For these large runoff events, the expected reduction in peak flows would result from temporary storage of flow in permanent impoundments and end lakes. Similar effects are described for the Proposed Action as a result of post-mining topography at the Three Oaks Mine. The effects of post-mining topography under conditions of average rainfall and stream flow are described below.

With precipitation contributions and evaporative withdrawals, a net loss of approximately 1,760 acre-feet per year is anticipated to be evaporated from the permanent surface water impoundments and end lakes at the Sandow Mine (Alcoa 1999). Following final reclamation at the Three Oaks Mine, a net loss of approximately 1,720 acre-feet per year is anticipated to be evaporated from the permanent surface water impoundments and end lakes at that site (Alcoa 2001b [Volume 5]). As a result, a total net loss of approximately 3,480 acre-feet per year is expected as a result of evaporation from open-water surfaces at the combined reclaimed sites. For comparison, current evaporative losses at Somerville Lake, assuming normal pool elevation, are approximately 19,000 acre-feet per year. Total evaporative losses in combination with storage and routing effects from the end lakes may create minor adverse impacts on downstream users. At most, the combined average effect may be to reduce downstream surface water yields by approximately 4 to 5 percent for Middle Yegua Creek, 1 to 2 percent for East Yegua Creek, and 12 percent for Big Sandy Creek. These estimates are based on regional watershed yield estimates and are for purposes of comparison only. The actual reduction in surface water yields likely would be less than these values, since the end lakes would discharge under favorable rainfall conditions, and these flows would pass through the downstream undisturbed watersheds under channel conditions that are the same as historical conditions. Most of the watershed area that would be controlled by the end lakes currently is drained by ephemeral channels that have contributed limited yields to downstream locations in the past. Evapotranspiration, aquifer conditions, seepage from the channels, and man-made withdrawals and contributions historically have affected such flows and would continue to do so. The existing large evaporative losses from Somerville Lake and the ongoing water supply management at that facility would outweigh the minimal relative effects of minor impacts from the mine. Along Big Sandy Creek, losing reaches occur where surface water infiltrates out of the channel and into the Simsboro outcrop. This is evident in comparing historical gaging data for the USGS stations near Elgin and McDade. Such pre-mining flow losses still would apply in the post-mining phase and would minimize the overall effects of end lake controls on watershed yield in Big Sandy Creek, since the flows may be lost to the aquifer or to evapotranspiration downstream, under pre-mining conditions.

As a result of recontouring during reclamation at both the Sandow Mine and the proposed Three Oaks Mine, approximately 22 square miles of watershed area would provide controlled contributions to downstream flows. Approximately 15.3 square miles of drainage area controlled by the end lakes would occur under the proposed Three Oaks reclamation configuration, and approximately 6.8 square miles would occur from Sandow. Approximately 6.4 square miles would be located in the Big Sandy watershed, approximately 11.7 square miles would occur in the Middle Yegua watershed, and approximately 4 square miles would occur in the East Yegua Creek watershed. In addition, approximately 11.5 square miles of watershed area drains to Alcoa Lake; however, this facility existed before USGS gaging started in the area in the early 1960s. Therefore, its effects are already included in the historical flow records that comprise the baseline condition.

These watershed modifications would not occur until after recontouring and reclamation at the mines. Effects of watershed modifications at Three Oaks are discussed as direct impacts under the Proposed Action (see Section 3.2.4.2). The effects from watershed modifications at Sandow will happen within the next 5 to 10 years and will consist of smaller flow rates and somewhat reduced flow durations on the intermittent or ephemeral reaches nearest the mine. Downstream of Sandow, additional tributaries join the channels and contribute flows. In the East Yegua drainage, flow impacts are likely to be negligible downstream of U.S. Highway 77. Upstream of the highway, approximately 3 miles of East Yegua Creek and 2 miles of the most upstream reaches of Allens Creek may be affected by restricted drainage area. The effects will diminish rapidly as other tributaries (e.g., Ham Branch, Rouse Branch) join the streams. Relatively small effects are likely to occur along Walleye Creek in the Middle Yegua drainage.

After reclamation, most of these areas still would contribute to streamflows, generally after large precipitation events during seasons of low evaporation. At such times, water in constructed lakes and ponds would overflow via spillways to the natural stream system. On average, this is likely to happen at intervals of less than 1 year, as discussed in relation to the RESOP modeling investigation presented for the Proposed Action (see Section 3.2.4.2). During low precipitation periods, these end lakes would not contribute runoff to streamflows in the channel system downstream of the reclaimed mines.

Additional past disturbance in the Big Sandy drainage has included approximately 1,000 acres of clay pits and related mining activities on three separate properties (see Section 2.6). These operations may have retained small amounts of runoff in the pits; however, the impact on the historical Big Sandy Creek flow regime likely has been minimal. Future potential impacts from these operations, assuming they comply with TPDES regulations, also are likely to be minimal. No cumulative effects on lower Big Sandy Creek, the Colorado River, or Brushy Creek are anticipated from surface disturbance or reclamation activities affecting surface water resources.

Effects to Surface Water Resources from Water Level Change. The projected cumulative groundwater drawdown from water supply pumping (see Section 3.2.3.2) potentially would affect surface water flows by decreasing baseflow contributions from the Simsboro aquifer or by increasing channel seepage losses in areas where the streams cross aquifer outcrops. The latter consequence would occur as runoff-generated streamflows in creekbeds above the water table infiltrate into unsaturated aquifer zones. These effects would decrease overall streamflows and low-flow discharges, and may decrease the extent and duration of any perennial pools that may exist in downstream proximity to the aquifer outcrops. The sources of springs also could be affected, and spring flows may decline or cease as a result. Projected impacts to baseflows were investigated for cumulative conditions using the same approach to identify gaining stream reaches as described under Effects to Surface Water Resources from Water Level Change in Section 3.2.4.2. No impacts to surface water baseflows or springs are anticipated from drawdown in the Calvert Bluff aquifer.

In an area on or immediately adjacent to the Simsboro outcrop and extending from the Colorado River to the northern end of the Sandow Mine, projected municipal water supply pumpage would create drawdown impacts on Big Sandy and Middle Yegua Creeks and their tributaries. Downstream of the mine, these impacts would be delayed by approximately 30 years as a result of artificial discharges from the Three Oaks Mine. A decrease in groundwater baseflow contributions potentially would occur from cumulative groundwater drawdown of greater than 20 feet in the Simsboro aquifer in the year 2030, and from greater cumulative drawdown in the year 2050. Due to the magnitude and extent of projected drawdown, these effects likely would be noticeable in all seasons after year 2030 when surface discharges to the streams cease. In the Big Sandy drainage, flow decreases would occur on Big Sandy Creek itself, Little Sandy Creek near the Three Oaks Mine area, Burlson Creek, Little Sandy Creek and other tributaries in the vicinity of State Route 95, lower Dogwood Branch, and on smaller unnamed tributaries entering Big Sandy Creek from the west near the Colorado River. Impacts from drawdown would be the largest on this system, since its entire length overlies or closely parallels the Simsboro outcrop. However, total streamflow still would be primarily dependent on rainfall runoff, and streams still would flow following rainfall events.

In their natural state, these streams likely vary from flow-gaining to flow-losing conditions between specific locations along the channels and between wet or dry periods. Under this scenario, flow contributions from groundwater would be minimal, and flow losses by seepage into the channel bed would increase in most seasons and years. These effects would be evident after year 2030 along the length of Big Sandy Creek and in most of its tributaries entering from the west. Net flow decreases are difficult to quantify but are likely to be on the order of 0.5 to 1.0 cfs on the larger streams. The largest potential impact would occur during the low-flow season when decreases in this general range represent all or most of the total flow. As a result, flows would be reduced or eliminated in portions of Big Sandy Creek and its larger tributaries (e.g., Burlson Creek and Little Sandy Creek). The extent and duration of perennial pools likely would not decrease, since any pools that occur would be maintained by rainfall runoff. Smaller tributaries that may be intermittent at least for short seasons in their natural condition are likely to become ephemeral (flowing only in response to sufficient precipitation).

In the Yegua Creek drainage, East Yegua Creek is not likely to be affected by groundwater drawdown in the Simsboro aquifer since the Sandow Mine topography isolates the channels from the outcrop. Municipal pumping impacts on a section of Middle Yegua Creek and its tributaries potentially would occur where they cross the Simsboro outcrop. A short reach of Middle Yegua Creek itself, Walleye Creek, Grass Creek, and Sandy Creek are likely to be affected. The nature of the potential drawdown impacts would be the same as that described for the Big Sandy Creek system; however, their magnitude generally would be less. These stream reaches would not be augmented by pumping discharges, so the effects of municipal drawdown would become more noticeable over the life of the mine. Middle Yegua Creek and most of its tributaries cross the Simsboro aquifer over short channel reaches and have additional contributing watershed areas that are not associated with the Simsboro outcrop. One exception is Sandy Creek (a tributary to Walleye Creek). Sandy Creek flows along the Simsboro outcrop for approximately 5 miles. Baseflow decreases in this channel likely would be on the order of 0.1 to 0.2 cfs (based on generally similar settings investigated in the permit area). This probably would be a substantial portion of the overall discharge during low flow periods. In general, flow decreases are anticipated to be restricted to these identified tributaries and a short reach of Middle Yegua Creek. Flows from additional contributing watershed areas (e.g., Willow Creek, Mine Creek, and Marshy Branch) enter Middle Yegua Creek within approximately 1 mile of the Simsboro outcrop. These contributing flows largely could mitigate baseflow effects from drawdown on Middle Yegua Creek farther downstream.

Approximately three springs along the Big Sandy system, and approximately three to four springs in the Middle Yegua headwaters, would be affected by groundwater drawdowns of 20 to 50 feet in the Simsboro aquifer by the year 2030. In the northwest corner of Lee County, flows from springs located on or near the outcrop in the Middle Yegua drainage (**Figure 3.2-21**) are likely to cease. Springs in the Big Sandy system occur on or near the outcrop at somewhat lower watershed positions. Flows at these latter locations are likely to decrease from their natural rates throughout the year and may cease in drier seasons. These impacts would increase in magnitude and duration by the year 2050.

Although recovery would occur in the proposed Three Oaks Mine vicinity after the cessation of mine-related pumping, estimated drawdowns for the years 2030 and 2050 still would range from approximately 30 to 60 feet in the Simsboro outcrop areas that likely contribute baseflow to the Big Sandy drainage and to Middle Yegua Creek. From a surface water perspective, the potential depths of drawdown still would be substantial enough under these later conditions to affect flows in drainages across the Simsboro outcrop in the area between the Colorado River and the Sandow Mine, as described. It is assumed that non-mining related pumping and its associated drawdown effects would exist in perpetuity.

Effects of Discharges to Streams. In recent years, an estimated combined annual average of approximately 28 cfs (20,300 acre-feet) has been discharged from the Sandow Mine into Walleye and East Yegua Creeks as a result of groundwater management at that mine. Walleye Creek joins Middle Yegua Creek several miles downstream of the discharge point. Historically, these discharges likely have been the source of prolonged low flows in the reaches of these streams near the mine. Depending on the actual discharge volume at one time and its distribution between the creeks, augmented flows likely have occurred for 10 to 15 miles downstream of the discharge points, as implied by baseline inventory data in lower Walleye Creek and USGS gage records for East Yegua Creek. The amount of augmentation on downstream reaches ranges between 8 and 12 cfs on Walleye Creek near the mine and decreases downstream due to seepage losses and evapotranspiration. The amount of augmentation on East Yegua Creek is approximately 20 to 25 cfs. These flows likely varied as a result of pumping and discharge changes at the Sandow Mine. These activities have affected surface water resources over the past decade or more.

The cessation of Sandow Mine dewatering and depressurization discharges would end artificial flow augmentation in East Yegua and lower Walleye Creeks in approximately 2005. As a result, flows in the augmented reaches would return from an essentially perennial regime to their original ephemeral or intermittent regime. Given that the affected stream reaches are relatively high in the watershed, it is likely that flows would cease during the summer and fall and during droughts, as do flows in undisturbed streams in similar nearby settings. Small intermittent or perennial pools may remain along isolated stretches of the channels during these dry periods. The end of augmentation would contribute to combined impacts on surface water resources as discussed below.

Flows in Middle Yegua Creek would not be affected by the end of Sandow Mine discharge into Walleye Creek until after the year 2030, when similar discharges from Three Oaks would end. Until that time, discharges from dewatering and depressurization pumping would augment Middle Yegua Creek below monitoring station LMY, and Big Sandy Creek below station UBS and Chocolate Creek as discussed under direct impacts for the Proposed Action (Section 3.2.4.2). As discussed, three TDPES outfalls are proposed for the Three Oaks Mine. All excess water would be discharged at these outfalls to Middle Yegua Creek and Big Sandy Creek. With average annual runoff included in the discharge estimates, the range of releases into Middle Yegua is estimated to be 13 to 18.5 cfs (9,400 to 13,400 acre-feet per year). Including average annual runoff, the overall range of combined releases into lower Big Sandy is estimated to be 3.3 to 9.7 cfs (2,400 to 7,000 acre-feet per year). It should be noted that these estimates are based on average conditions; the actual rates could vary substantially from these estimates depending on pumping rates, mine water use, mitigation demands, and the occurrence of large storm events. Typical discharge rates likely would be somewhat smaller than the ranges presented; however, it may increase substantially for periods of days or weeks following storms. During these events, native flows in the downstream channels also would be larger. Regionally, this partially would offset the effects from cessation of discharges at Sandow until the year 2030, and until that year it would outweigh the effects of groundwater drawdown on the main channels of Big Sandy Creek and Middle Yegua Creek.

Effects on Surface Water Rights. The potential effects on surface water rights under this cumulative scenario would be similar to those discussed under the Proposed Action (see Section 3.2.4.2). A slight increase in adverse effects on downstream water users may be anticipated beyond those described for the Proposed Action. This would result from combined evaporative effects in the Three Oaks Mine and Sandow Mine end lakes, as discussed previously in this cumulative scenario under Effects from Watershed Modifications. As discussed previously under the Proposed Action, RRC regulations require Alcoa to mitigate adverse effects on water supplies. Therefore, cumulative effects on surface water rights under the Three Oaks without SAWS scenario would be minimized.

<u>Three Oaks with SAWS</u>

Potential impacts to surface water resources under this scenario would be similar to those discussed for Three Oaks without SAWS, except that the quantity of water pumped for SAWS would correspondingly reduce the quantity of water to be pumped for mine depressurization. Potential impacts from groundwater drawdown also would be similar; however, increased water supply pumping with SAWS would have a regional effect on gaining stream segments that occur northward along the Simsboro outcrop. No surface water quality impacts are anticipated.

Removal of Surface Water Features. These activities and their effects would be the same as those described for Three Oaks without SAWS.

Effects from Watershed Modifications. The effects on streamflow from watershed modification would parallel those described for the Three Oaks without SAWS scenario.

Effects to Surface Water Resources from Water Level Change. Under this scenario, the projected effects to surface water resources from water table drawdown would be essentially the same as those discussed for the Three Oaks without SAWS scenario. However, increased groundwater pumpage and resulting drawdown also would affect regional gaining stream segments northward along the Simsboro outcrop. Prior to the year 2013, groundwater drawdown effects on downstream main channels still would be overshadowed by the contributions to streamflow from Three Oaks discharges into Big Sandy and Middle Yegua Creeks as discussed below. Tributary drainages would be affected by drawdown during the life of the mine. After the year 2013, the average flow augmentation of Middle Yegua and Big Sandy Creeks from pumping and discharge would decline and cease as a result of SAWS withdrawing the former depressurization discharges for water supply, as discussed above. However, during the life of the mine, storm runoff discharges into the creeks generally would outweigh drawdown effects below the proposed TPDES outfalls. Late season flow rates would decrease and perennial pools (which are limited in the baseline condition) would be subject to decreases in duration and extent, particularly in gaining reaches or channels immediately downstream of the pools.

Effects of Discharges to Streams. Prior to 2013, the potential effects to surface waters as a result of discharge would be the same as described above for the Three Oaks without SAWS scenario. In 2013, SAWS would begin to withdraw groundwater from the Three Oaks Mine area. Given current estimates of depressurization pumpage, dewatering pumpage, and localized industrial uses (e.g., mine dust control), on average, this would result in removing the discharge contributions from the main channels of Big Sandy Creek and Middle Yegua Creek at the proposed TPDES outfalls. It should be noted that in periods of high runoff, substantial discharges from the mine water management system still would occur, and these essentially would maintain the intermittent flow character of the downstream channels during the life of the mine.

The combined effects on Big Sandy Creek and Middle Yegua Creek would include greater flow below the outfalls until Three Oaks stops discharging depressurization water in the year 2013. Between 2013 and 2030, late-season flows and the occurrence of perennial pools on or near gaining reaches likely would decrease or cease on both drainages as a result of drawdown. After the year 2030, the cumulative effects described for surface water resources generally would act in combination on Big Sandy and Middle Yegua Creeks. Flows and perennial pools in these channels substantially would be reduced by a combination of watershed yield decreases and groundwater drawdown effects on baseflow contributions from the Simsboro aquifer. These impacts would be most noticeable near the proposed Three Oaks Mine permit area and for several miles downstream on both creeks. It is conceivable that average flow reductions of 25 percent or more could occur in these areas. As a result, seasonal impacts could be greater. Potential impacts from the Three Oaks Mine in these areas gradually would be alleviated after 2030 as the Simsboro aquifer recovers in the immediate vicinity of the Three Oaks Mine. However, throughout the watersheds in general, such alleviation would be offset by increasing drawdown from water supply pumping. It is assumed that the municipal water supply pumping and its associated drawdown effects would exist in perpetuity.

East Yegua Creek would be affected by watershed modifications and the cessation of discharges at the Sandow Mine. Flows would be substantially reduced near the mine from their existing artificially augmented condition. These impacts would be greatest upstream of State Route 77; however, some decreases in flow and the size and duration of perennial pools downstream of this location could occur. These effects would result from the change in the augmented flow conditions that have existed from Sandow Mine discharges.

Effects on Surface Water Rights. No surface water users are recorded along the Yegua system channels in the mining vicinity. Thus, no effects are anticipated on Big Sandy, Middle Yegua, and East Yegua Creeks from operations and reclamation activities at the existing Sandow Mine or the proposed Three Oaks Mine. Riparian uses may temporarily benefit from additional flows along Big Sandy and Middle Yegua Creeks as a result of Three Oaks Mine discharges. After reclamation at Sandow and Three Oaks, restored water features likely would offset potential impacts to riparian uses. Riparian rights that are adversely affected by mine-related groundwater drawdown would be mitigated or compensated for by Alcoa in accordance with RRC regulations. On the Big Sandy and Middle Yegua drainages, both riparian uses and any recorded water rights may be adversely affected after the year 2030 by groundwater drawdown induced by SAWS and other municipal pumping, as discussed below for the cumulative No Action Alternative (SAWS without Three Oaks).

The potential for more widespread impacts to surface water resources from mine watershed modifications or surface water discharge would be extremely limited. At Somerville Lake and below, USACE reservoir operations determine the Yegua Creek flow conditions downstream to the Brazos River and associated irrigated lands. The watershed area contributing to Somerville Lake is approximately 1,003 square miles, and the restricted drainage areas affected by Alcoa's post-mining topography areas represent slightly over 2 percent of that area. These effects would have a minor adverse impact on downstream water users, since their magnitude is small relative to overall watershed yield. In fact, most downstream users are recorded at locations much farther downstream in the watersheds and are hydraulically separated from the mined areas by stream reaches in all three creeks that frequently go dry in the late summer and fall.

Regional cumulative impacts on surface water resources from SAWS and municipal pumping may result in adverse effects on surface water rights. These impacts would be addressed through state, regional, or local water management authorities. Riparian and other surface water rights along the Big Sandy and Middle Yegua drainages and their tributaries in the vicinity of the Simsboro outcrop would be adversely affected by groundwater drawdown impacts from SAWS and other pumping. On average, these impacts would decrease the volume of water available and shorten the duration of use. During any critical future drought period in which surface water rights are tested, those groundwater contribution areas of Big Sandy Creek most likely to be affected probably do not contribute to any flows in the Colorado River. In addition, when they presently do contribute to Colorado River flows (in the winter and early spring months), the flows are so small compared to target Colorado River flows at Bastrop that any effects are minimal. As a result, water rights impacts on the Colorado River would not occur under this scenario.

SAWS without Three Oaks (No Action Alternative)

The potential surface water impacts under the SAWS without Three Oaks scenario relate to effects on streamflow magnitudes and durations as a result of water supply pumping. Little or no impacts on surface water quality are anticipated.

Removal of Surface Water Features. Under this scenario, removal of existing surface water features only would occur at the Sandow Mine. Acreages of disturbance to surface water features at the Sandow Mine is estimated to include a total disturbance of approximately 117.8 acres of ponds and ephemeral/intermittent streams. The direct loss of these resources would be mitigated in accordance with Alcoa's existing permits.

Effects from Watershed Modifications. Effects on streamflows from watershed modifications at the Sandow Mine would be the same as described under the Three Oaks without SAWS scenario. No watershed modifications would occur at Three Oaks Mine as the mine would not be developed.

Effects to Surface Water Resources from Water Level Change. In the area between the Colorado River on the south and the Sandow Mine on the north, the projected effects on surface water resources from water table drawdown under this scenario would be similar to those discussed for Three Oaks with and without SAWS. Large areas experiencing drawdown over 20 feet are projected in areas of gaining stream channels, springs, and reaches that could experience seepage losses. The occurrence of these areas would be similar to the cumulative scenarios described above for Three Oaks with and without SAWS as Three Oaks Mine pumpage would have little effect in these areas.

On a more regional basis, flow contributions from the Big Sandy into the Colorado River near Bastrop would decline as a result of extensive drawdown from SAWS and municipal water supply pumping in the Simsboro aquifer, as described for the Three Oaks with SAWS scenario. Regional pumping would affect surface water baseflows northeastward along the Simsboro outcrop into Milam, Robertson, Falls, and Limestone Counties. It is assumed that pumping for SAWS and other water supplies would occur in perpetuity, and thus the associated drawdown effects on surface water resources would as well.

Effects of Discharge to Streams. Under this scenario, discharges from Sandow Mine dewatering and depressurization groundwater pumpage to East Yegua Creek and lower Walleye Creek would cease in approximately 2005. As a result, flows in augmented reaches would return to their original ephemeral or intermittent regime, with small intermittent or perennial pools potentially remaining in isolated stretches. No discharge from the Three Oaks Mine would occur, as the mine would not be developed.

Effects on Surface Water Rights. As described for Three Oaks with SAWS, adverse impacts on surface water rights may result from regional cumulative impacts. Riparian and other surface water rights along Big Sandy Creek, Middle Yegua Creek, and their tributaries in the vicinity of the Simsboro outcrop would be adversely affected by groundwater drawdown impacts from SAWS and municipal pumping. These impacts would be similar to those described under the Three Oaks with SAWS scenario. The impacts could be mitigated through water resources management alternatives by local and regional authorities.

3.2.4.4 Monitoring and Mitigation Measures

<u>SW-1</u>: End Lake Shoreline Mitigation. During final design and implementation of end lake construction and reclamation at the proposed Three Oaks Mine, the USACE and other appropriate resource agencies would be consulted with regard to grading and recontouring along the projected shoreline margins. This consultation would ensure adequate inundation of the shoreline under conditions of fluctuating end lake water levels for the protection of surface water users.

<u>SW-2</u>: End Lake Outlet/Channel Mitigation. During final design and implementation of end lake construction and reclamation at the proposed Three Oaks Mine, the outlet spillways and downstream channel protection measures would be configured and implemented so as to minimize the potential for channel degradation and downstream sedimentation. The measures would be constructed so as to provide long-term channel protection.

<u>SW-3</u>: Stream Crossing Mitigation. During final design and construction of culverts and bridge crossings for the proposed Three Oaks Mine, TNRCC and USACE would be consulted to avoid adverse changes to stream channel cross-sectional geometry and to coordinate the review and approval of BMPs. This would be done in order to minimize adverse impacts from erosion, sedimentation, and potential effects on aquatic habitat features due to cross-sectional or longitudinal modifications.

<u>SW-4</u>: Surface Water Flow Mitigation. Alcoa would coordinate and plan pumping discharges through the TPDES outfalls for the proposed Three Oaks Mine in a manner to provide continuous surface flows at the three outfalls to the degree possible during low-flow periods. The purpose of such coordination and planning

would be to alleviate the potential impacts of groundwater drawdown on surface water low flows during the active mining phase.

3.2.4.5 Residual Adverse Effects

The creation of end lakes in the final reclaimed configuration would control the discharge of storm runoff in adjacent downstream portions of Willow Creek, upper Mine Creek, and Chocolate Creek. The amount and timing of storm runoff in these ephemeral streams would be modified from the pre-mining conditions. Average annual surface water yields along Mine Creek and Chocolate Creek are predicted to be somewhat reduced. These effects would diminish downstream as storm flows from undisturbed tributaries contribute to yields from the larger watershed areas. The end lakes themselves would change the nature of existing surface water resources from geographically distributed small streams and ponds to that of relatively larger, deeper features on the reclaimed surface. These effects would be somewhat reduced by the establishment of drainage features and ponds as reclamation proceeds.

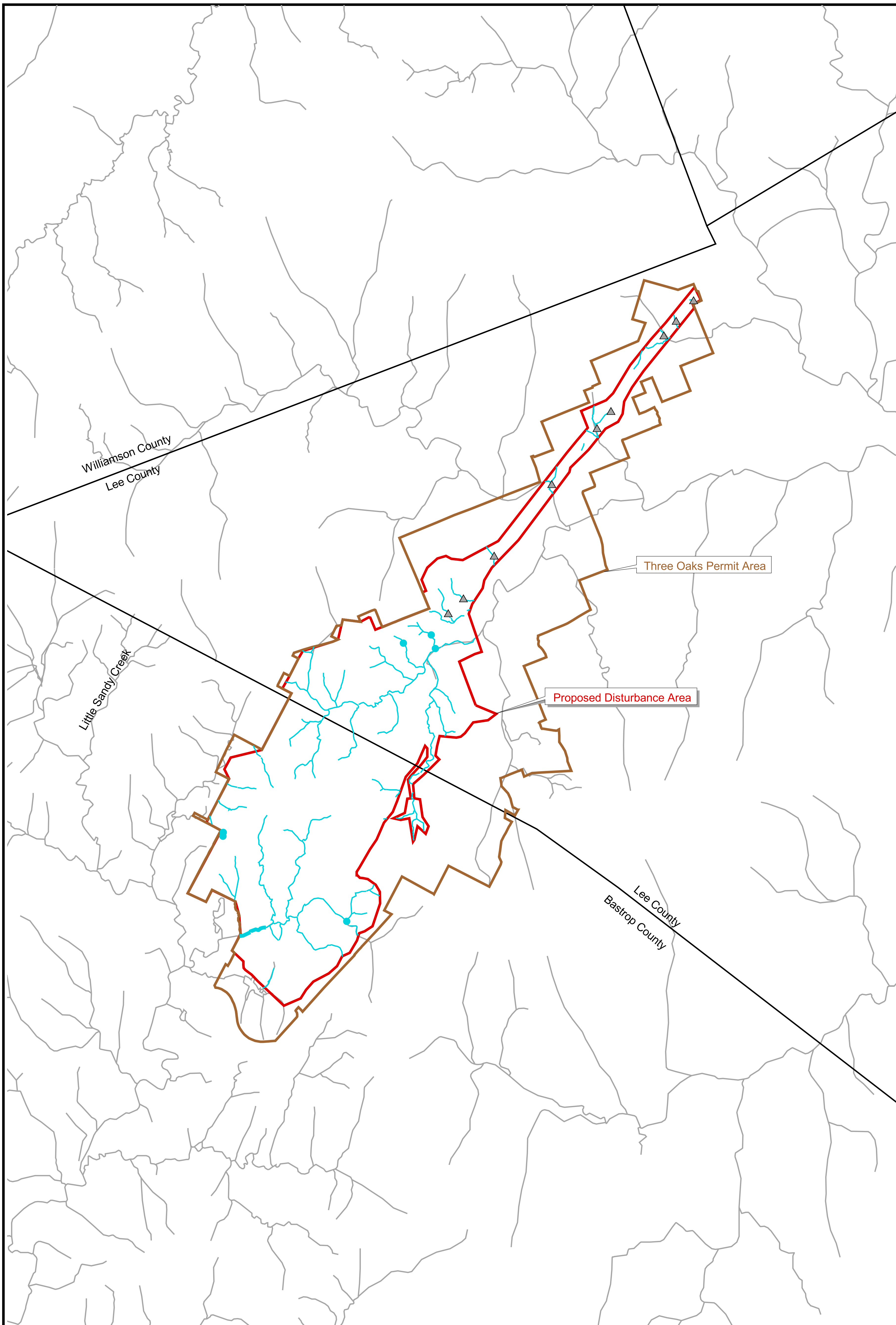
The predicted water table drawdown from dewatering and depressurization pumping would reduce baseflow contributions in stream reaches where such flows occur. These effects are most likely to occur on isolated stream channels overlying the Simsboro outcrop, and in channels immediately downstream from such reaches. Elsewhere in the study area, most stream flows are supported by rainfall runoff. Flow reductions would be most notable in the areas of groundwater contributions during seasonal low-flow periods, when baseflow contributions from groundwater would be most likely to comprise a substantial portion of the streamflow in the affected channels. Under existing conditions, streams typically are reduced to zero flows in the area during parts of the year, and the adverse impacts from water table drawdown would mimic, but expand, this occurrence. Several decades after pumping ceases, such impacts are predicted to cease when the aquifer zones that contribute to stream flows recover.

3.2.5 Waters of the U.S. Including Wetlands

3.2.5.1 Affected Environment

Field surveys were conducted in June 2000 to identify waters of the U.S., including wetlands, within the permit area (Horizon 2000); identified waters of the U.S. including wetlands are shown in **Figure 3.2-25**. Prior to conducting wetland delineation activities, Horizon reviewed NRCS soil survey information, USGS topographic maps, and ortho-rectified color infrared aerial photography (dated 1995) to identify the general locations of wetlands and other waters of the U.S. Wetland delineations were conducted according to the methodology described in the USACE 1987 Wetland Delineation Manual (USACE Manual) (USACE 1987).

The study area for waters of the U.S., including wetlands, includes the proposed disturbance area, the projected mine-related 10-foot groundwater drawdown area within the Simsboro aquifer outcrop, and segments of Big Sandy and Middle Yegua Creeks extending approximately 6 miles downstream from the points of proposed mine water discharge. The general locations of waters of the U.S., including wetlands,



Legend:

Waters of the U.S. (Wetlands)

Waters of the U.S. (Streams)

Culvert for Stream Crossing

Source: Stream data adapted from Figure 2 (.133 Appendix 6), Horizon 2000.

N

0 0.5 1 Miles

Three Oaks Mine

Figure 3.2-25
Waters of the U.S. Including Wetlands in the Permit Area

that occur outside of the proposed disturbance area, but within the study area, were identified based on National Wetland Inventory (NWI) maps developed by the USFWS. Waters of the U.S., including wetlands, identified on these maps have not been field verified. Based on data review and field surveys, 10 wetlands comprising approximately 9 acres occur within the study area. Within the proposed disturbance area, the field surveys identified approximately 198,481 linear feet of waters of the U.S. (i.e., ephemeral and intermittent creeks) totaling approximately 23.6 acres. Additionally, there are approximately 38.5 acres of on-channel ponds and 5.3 acres of wetlands located within the proposed disturbance area (Hodges 2002b). Review of NWI and USGS topographic maps indicate that within the portion of the study area located outside of the proposed disturbance area, there are approximately 78,000 linear feet of waters of the U.S. Field surveys of this area were limited by lack of access. Based on limited field observations plus interpretation of color infrared aerial photography, this portion of the Simsboro outcrop outside of the permit area was estimated to contain approximately 73.5 acres of waters of the U.S. (Horizon 2002). As a result, a total of approximately 276,481 linear feet of ephemeral and intermittent stream channel qualifying as waters of the U.S. and totaling approximately 140.4 acres are estimated to occur within the study area (**Figure 3.2-26**).

The majority of wetlands observed within the permit area were classified as palustrine emergent wetlands associated with depressions adjacent to intermittent creeks or fringe areas along the edges of stock pond embankments or roadways (Horizon 2000). Dominant herbaceous species observed within these wetlands included smartweed (*Polygonum* spp.), spikerush (*Eleocharis* spp.), flatsedge (*Cyperus* spp.), and rush (*Juncus* spp.). Tree and shrub species occasionally observed in the wetlands included black willow (*Salix nigra*), eastern cottonwood (*Populus deltoides*), sugar hackberry (*Celtis laevigata*), and cedar elm (*Ulmus crassifolia*). Wetland soils primarily consisted of clayey sands that exhibited distinctive hydric characteristics (e.g., mottling) (Horizon 2000). Wetland vegetation is discussed further in Section 3.4.1.1, Vegetation Types.

Riparian woodlands within the permit area are located along the edges of intermittent and ephemeral streams. These riparian corridors are characterized by a dense overstory canopy and a well developed understory consisting of a variety of shrub and herbaceous species. These riparian woodlands did not meet the requirements for waters of the U.S. (Horizon 2000). An additional description of riparian woodlands is provided in Section 3.4.1.1, Vegetation Types.

The cumulative effects area for waters of the U.S., including wetlands, includes the proposed Three Oaks Mine disturbance area; the projected interrelated actions' 10-foot groundwater drawdown area within the Simsboro aquifer outcrop; segments of Big Sandy, Middle Yegua, and East Yegua Creeks extending approximately 6 miles downstream from the points of discharge from interrelated actions; and areas of surface disturbance associated with interrelated actions (**Figure 2-15**). Wetlands within the cumulative effects area were evaluated using NWI maps, color infrared photography, and field survey data, where available. Review of the NWI maps and aerial imagery indicates the presence of numerous stock pond impoundments in the region, as was observed during field surveys within the permit area. These total approximately 31.4 acres within the proposed disturbance area. The isolated stock ponds observed within the permit area generally do not support wetland vegetation and were assessed as being non-jurisdictional (Horizon 2000). Review of maps and photos for the 10-foot drawdown area of the Simsboro aquifer outcrop indicated that the majority of stock ponds in this area also are isolated off-channel ponds that would not meet the definition of waters of the U.S. (Horizon 2002). Most of these ponds had limited vegetation around their perimeters, while a few had substantial stands of hydrophytic vegetation. The majority of wetlands identified within the cumulative effects area are small, isolated emergent wetlands. It is assumed that the conditions within these wetlands are similar to the conditions identified in the wetlands delineated within the permit area. Ephemeral and intermittent channels also occur within the cumulative effects area. Due to the lack of access, field verification of NWI mapped waters of the U.S., including wetlands, within the cumulative effects area could not be performed (other than within the permit area). However, as the majority of channels in the region are intermittent or ephemeral, the streams are likely to be waters of the U.S. It is assumed that insufficient streamflow exists to sustain riparian wetland corridors adjacent to ephemeral and intermittent streams outside of the permit area other than along the segments of Walleye and East Yegua Creeks that currently receive flow from Sandow Mine groundwater discharge.

3.2.5.2 Environmental Consequences

Proposed Action

Physical Disturbance, Removal, and Replacement of Waters of the U.S. Including Wetlands. A total of 8.7 acres of wetlands, all of which are waters of the U.S., occur within the permit area, of which 5.3 acres would be adversely affected as a result of mine construction and operation. The direct impacts would occur as a result of mine pit construction and development of ancillary facilities, including haul roads, conveyors, storage buildings, parking lots, and storm water control structures. A total of 67.4 acres of waters of the U.S., including 19.9 acres of ephemeral stream channels, 3.7 acres of intermittent stream channels, and 38.5 acres of on-channel ponds also would be directly impacted during mine operation. Waters of the U.S., including wetlands, that would be affected within the permit area are shown in **Figure 3.2-25**. These impacts would be minimized through implementation of the proposed reclamation program that would be initiated following backfill of the initial mine pit and would continue concurrent with mine operations. As discussed in Section 2.5.3.6, Restoration of Waters of the U.S. Including Wetlands, and as contained in Alcoa's draft Mitigation Plan (Appendix E), the goal of the reclamation program for wetlands, riparian woodland, and surface water features is to create features of similar nature and function to those existing prior to mining. Alcoa's mitigation of waters of the U.S., including wetlands, would involve a combination of onsite replacement of features removed within the area disturbed by mining plus creation or enhancement of additional features in an offsite protected area along Mine Creek and Middle Yegua Creek (the Middle Yegua Mitigation Site).

Direct impacts to low-quality ephemeral streams would be mitigated at a minimum replacement ratio of 1:1 (based on the area of affected stream channel) (see Section 3.2.4.2). Medium-quality streams would be mitigated at a minimum ratio of 1.5:1. High-quality streams and herbaceous wetlands would be replaced at a minimum ratio of 2:1. On-channel ponds (qualifying as waters of the U.S.) would be reclaimed at a minimum ratio of 1.5:1. Temporal impacts would be mitigated at a ratio of 0.5:1. Based on these mitigation ratios, the total proposed mitigation acreage for direct impacts would include restoration of at least 23.6 acres of stream channel, 5.3 acres of wetlands, and 57.8 acres of on-channel ponds within the reclaimed mine area plus creation of 5.3 acres of new wetlands and 20.6 acres of stream channel/riparian enhancement in the Middle Yegua Mitigation Site. The total proposed mitigation acreage for temporal impacts would include

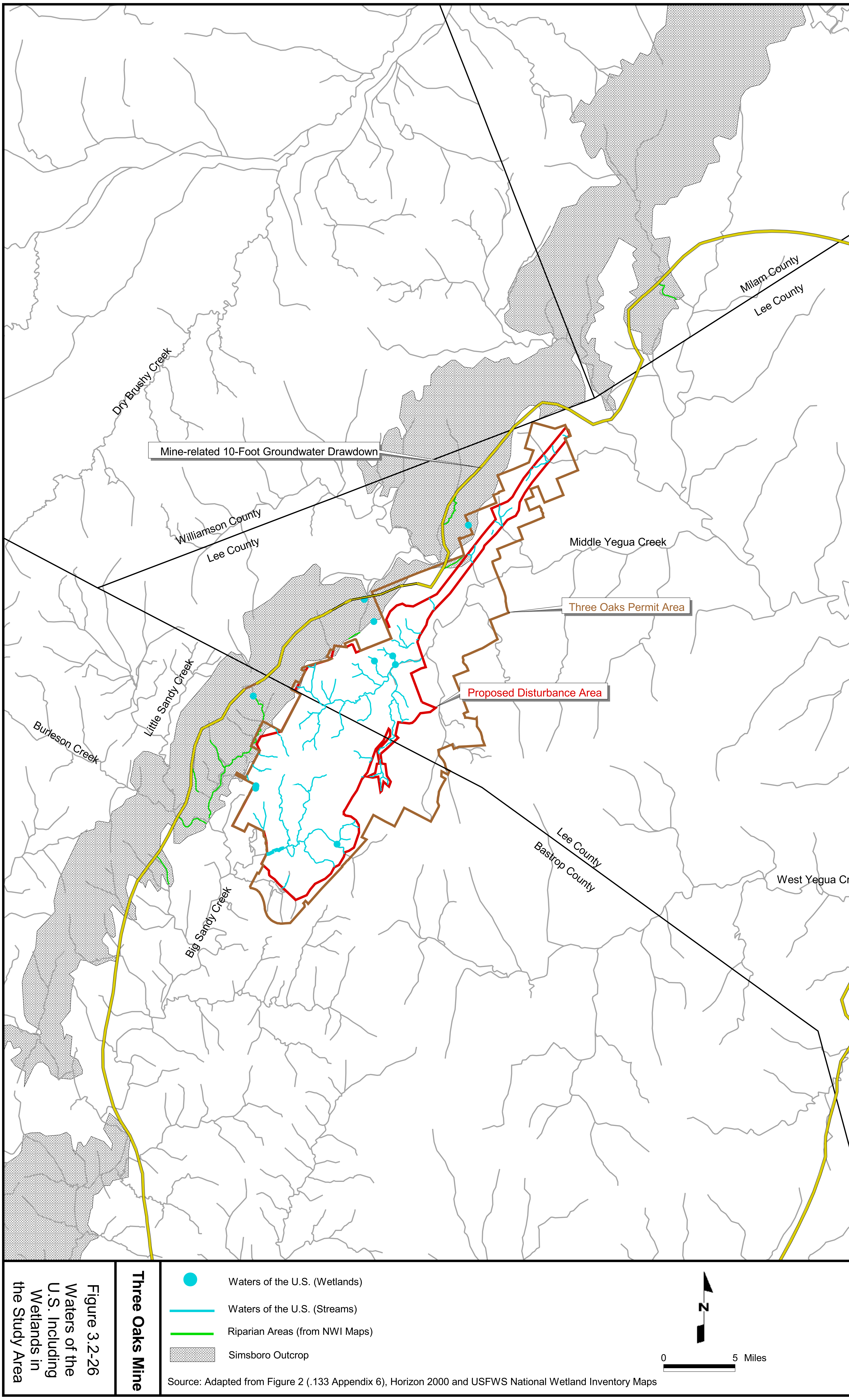


Figure 3.2-26 Waters of the U.S. Including Wetlands in the Study Area

Three Oaks Mine

23.6 acres of stream channel/riparian enhancement and 2.7 acres of new wetlands in the Middle Yegua Mitigation Site.

The temporary loss of 5.3 acres of wetlands during mining operations would result in the loss of the functions associated with each area (e.g., runoff and sediment retention), affecting water quality. This loss would be mitigated by creation of 8.0 acres of additional wetlands in the Middle Yegua Creek mitigation site and restoration after mining of 5.3 acres of wetlands in the disturbance area. Additionally, the removal of jurisdictional streams would reduce the available flow pathways for runoff water. However, the implementation of storm water management plans, including the construction of sediment ponds and diversion channels, likely would provide comparable or greater storm water management capacities than the affected waters of the U.S. In addition, Alcoa's commitment to mitigation for intermittent and ephemeral streams that are waters of the U.S. and on-channel ponds would further enhance runoff and sediment retention at the mine site. The net increase in wetlands following reclamation would provide for additional capture of runoff and increased storm water and sediment retention.

Water Quantity Impacts. Dewatering of the Calvert Bluff aquifer would be limited to isolated sand lenses in the lower third of the Calvert Bluff Formation. As discussed under Groundwater Quantity Impacts in Section 3.2.3.2, groundwater drawdown associated with dewatering activities would be restricted to the lower portion of the aquifer based on modeling results. Due to the general lack of sand in the Calvert Bluff and the lack of surface waters supported by the Calvert Bluff water table, groundwater drawdown in the Calvert Bluff aquifer would not affect surface water features, including waters of the U.S. Depressurization of the Simsboro aquifer would occur during the life of the mine. As the Simsboro aquifer is confined well below the surface within the permit area, impacts to surface water features, including wetlands, within the permit area are not anticipated from Simsboro aquifer depressurization (see Section 3.2.3.2). Groundwater drawdown would occur within the Simsboro aquifer outcrop, located adjacent to the northwest boundary of the permit area. The anticipated drawdown within the outcrop area could reach a depth of 10 feet within the 10-foot drawdown area of the Simsboro outcrop. Field delineations of wetlands within the Simsboro outcrop area were not conducted; however, NWI maps and aerial imagery were reviewed to determine the number and extent of wetlands within the groundwater drawdown area of 10 feet and greater in order to estimate the potential impacts to wetlands. Based on this review, approximately 5.2 acres of jurisdictional wetlands that potentially could be affected by water level changes in the Simsboro outcrop were identified. In addition, seven riparian corridors associated with gaining stream reaches in the 10-foot drawdown area of the Simsboro outcrop, as identified from NWI maps, potentially would be affected by drawdown. The riparian corridors are associated with Big Sandy Creek, Little Sandy Creek, Burlson Creek, Middle Yegua Creek, and various tributaries to these waters located outside of the permit area. The area of jurisdictional creeks, tributaries, and drainages in the Simsboro aquifer outcrop within the projected 10-foot drawdown zone was estimated to be 11.5 acres, with an additional 56.8 acres of on-channel ponds (Horizon 2002). Gaining reaches of jurisdictional waters of the U.S. also may be affected by drawdown within the Simsboro outcrop. A detailed evaluation of potential impacts to gaining streams is discussed under Surface Water Quantity Impacts in Section 3.2.4.2, Waters of the U.S. Including Wetlands, within the study area are shown in **Figure 3.2-26**.

Water Quality Impacts. Construction of the Three Oaks Mine likely would result in temporary increases of sediment loading to ephemeral and intermittent streams leaving the permit area. It is likely that these increases would be minor and would occur only during initial construction activities while sediment and surface water management systems are being installed. During active mining operations and following mine reclamation, the sediment yield to local streams likely would be reduced below pre-mining levels due to implementation of the sediment and surface water control plans for the operation. A long-term reduction in sediment contribution could lead to changes in the channel substrates for adjacent downstream reaches of the receiving streams. This change in sediment contribution is expected to be minor in magnitude and be substantially attenuated beyond the nearest downstream impoundment or tributary confluence on each drainage. No other impacts to water quality for waters of the U.S. are anticipated.

No Action Alternative

Under the No Action Alternative, the Three Oaks Mine would not be developed. As a result, impacts to quantity and quality of jurisdictional waters of the U.S. and wetlands resulting from the proposed Three Oaks Mine as described above would not occur. The existing features, flow regimes, and water quality characteristics would remain in their existing conditions. Annual and seasonal changes in water level, flow, and water quality characteristics would continue as they have in the past.

3.2.5.3 Cumulative Impacts to Waters of the U.S. Including Wetlands

Three Oaks without SAWS

Physical Disturbance, Removal, and Replacement of Waters of the U.S. Including Wetlands. The existing Sandow Mine has affected waters of the U.S., including wetlands, as a result of mine development and construction of ancillary facilities. The Sandow Mine will affect approximately 60.6 acres of wetlands and 117.8 acres of other waters of the U.S. prior to mine closure and final reclamation. Reclamation at the Sandow Mine will include the construction of 108.6 acres of wetlands and 131.1 acres of other waters of the U.S. As a result of the reclamation activities, a net increase of 48 acres of wetlands will be created relative to pre-mining conditions. Additionally, a total of 772 acres of developed water features (i.e., ponds and end lakes) will be created as a result of reclamation activities.

Data describing wetland impacts related to the Rockdale power generating station and aluminum smelter, clay mining operations, and Powell Bend Mine were not readily available for review; therefore, it is not possible to quantify impacts to waters of the U.S., including wetlands, associated with these facilities. However, the Rockdale power generating station is located adjacent to Alcoa Lake, and the Lost Pines 1 and Sim Gideon power plants are located adjacent to Lake Bastrop; these lakes were created as the sources of cooling water for the plants. It is assumed that the creation of the 895-acre Alcoa Lake and the 900-acre Lake Bastrop resulted in a substantial increase in waters of the U.S. and associated fringe wetlands (i.e., wetlands located along the lake shore) as well as altering the hydrology and sediment dynamics of these watersheds.

Although it is difficult to quantify the number and extent of impacts to waters of the U.S., including wetlands, in the region, it is assumed that a net cumulative gain of waters of the U.S., including wetlands, would occur as a result of these past, present, and reasonably foreseeable future actions including the proposed Three Oaks Mine. This gain is mainly attributed to the creation of Lake Bastrop for the Lost Pines 1 and Sim

Gideon Power Plants and Alcoa Lake for the Rockdale power generating station, which substantially increased the acreage of jurisdictional waters of the U.S., including wetlands, in the cumulative effects area. This net gain, however, occurs in the context of overall impacts associated with changes in the natural dynamics of these watersheds.

Water Quantity Impacts. Groundwater generated from aquifer depressurization pumpage at the Sandow Mine is currently discharged into East Yegua and Walleye Creeks. This discharge provides a perennial flow to these waters of the U.S., contributing to an increase in riparian vegetation along the channels. Upon closure and reclamation of the Sandow Mine, groundwater discharge will cease and the channels will revert back to intermittent flows, likely causing a reduction in existing established riparian vegetation. Minewater discharge from the Three Oaks Mine would occur in Middle Yegua, Big Sandy, and Chocolate Creeks. The flow in these creeks would become perennial during the life of the mine, likely causing an increase in riparian vegetation along these channels at approximately the same time riparian vegetation is being reduced at East Yegua and Walleye Creeks. Upon closure of the Three Oaks Mine, the flow would revert back to intermittent, likely reducing the temporary riparian vegetation established during the discharge period.

Between the Colorado River on the south and the Sandow Mine on the north, waters of the U.S. likely would be affected in gaining reaches of stream channels where baseflow is received from groundwater sources in the 20-foot or greater drawdown area of the Simsboro aquifer and immediately downstream of these reaches. Impacts to gaining streams from municipal groundwater withdrawal are discussed in Section 3.5.4.3, Cumulative Surface Water Impacts. Wetlands within the drawdown area of the Simsboro aquifer outcrop that are fed by groundwater also may be affected by municipal groundwater withdrawal where groundwater drawdown is greater than seasonal fluctuations.

Water Quality Impacts. During active operations and following mine reclamation, the Three Oaks Mine likely would result in reduced sediment loading to ephemeral and intermittent streams leaving the permit area, due to implementation of the sediment and surface water control plans for the operation. A change in sediment contribution could lead to changes in the channel substrates for downstream reaches of these streams. These changes are expected to be substantially attenuated by the first downstream impoundment or tributary confluence on each drainage. Thus, they are not expected to contribute to cumulative effects. No other cumulative impacts to water quality for waters of the U.S. are anticipated.

<u>Three Oaks with SAWS</u>

Physical Disturbance, Removal, and Replacement of Waters of the U.S. Including Wetlands. Under this scenario, direct impacts to waters of the U.S. would be similar to the surface disturbance discussed for the Three Oaks without SAWS scenario.

Water Quantity Impacts. Up to year 2013, the effects of groundwater discharge would parallel those described under the Three Oaks without SAWS scenario. However, with the initiation of SAWS in year 2013, groundwater depressurization pumpage no longer would be discharged from the Three Oaks Mine. As a result, flows in Middle Yegua, Big Sandy, and Chocolate Creeks would return to intermittent conditions that likely would reduce temporary riparian vegetation established during discharge and could result in alteration of the channel substrate.

Between the Colorado River on the south and the Sandow Mine on the north, potential impacts to waters of the U.S., including wetlands, largely would be related to surface water flow magnitudes and durations. The projected groundwater drawdown from groundwater pumpage for the Three Oaks Mine and SAWS and other municipal pumping likely would affect surface water flows by decreasing baseflow contributions from the Simsboro aquifer and by increasing channel seepage losses in areas where the waters of the U.S. cross aquifer outcrops. Gaining reaches of waters of the U.S. within the 20-foot drawdown contour of the Simsboro aquifer outcrop could lose groundwater contributions, causing a reduction in riparian areas and perennial pools downstream of these reaches. Wetlands in the outcrop area that are fed by groundwater may be affected where drawdown is greater than seasonal fluctuations. These impacts, as discussed earlier, would include a decrease in water availability for wetlands, causing a potential decrease or loss of affected wetlands. Although increased drawdown could potentially affect wetlands, a net gain of waters of the U.S., including wetlands, is projected as a result of the reclamation programs associated with past, present, and reasonably foreseeable future actions, including the proposed Three Oaks Mine.

Water Quality Impacts. Under this scenario, cumulative impacts to waters of the U.S. would be similar to the water quality impacts discussed for the Three Oaks without SAWS scenario.

<u>**SAWS without Three Oaks (No Action Alternative)**</u>

Physical Disturbance, Removal, and Replacement of Waters of the U.S. Including Wetlands. Under this scenario, direct impacts to waters of the U.S., including wetlands, would be limited to surface disturbing activities associated with the existing Sandow Mine, Rockdale power generating station and smelter, clay mining operations, and Powell Bend mine. Direct impacts and beneficial effects associated with these facilities are described under the Three Oaks without SAWS scenario.

Water Quantity Impacts. Between the Colorado River on the south and the Sandow Mine on the north, effects on waters of the U.S., including wetlands, from groundwater drawdown would be similar to those described above for the Three Oaks with and without SAWS scenarios.

Water Quality Impacts. This scenario would not include the expected changes in sediment loading associated with the proposed Three Oaks Mine. Thus, sediment contribution would continue at existing levels from this area to local drainages above the nearest downstream impoundments unless changes result from other unidentified development projects in the vicinity.

3.2.5.4 Monitoring and Mitigation Measures

Alcoa's draft Mitigation Plan (Appendix E) currently is being reviewed by the USACE. Additional monitoring and mitigation measures may be considered for waters of the U.S. pending the outcome of this review.

3.2.5.5 Residual Adverse Effects

No residual adverse effects to waters of the U.S. including wetlands have been identified.